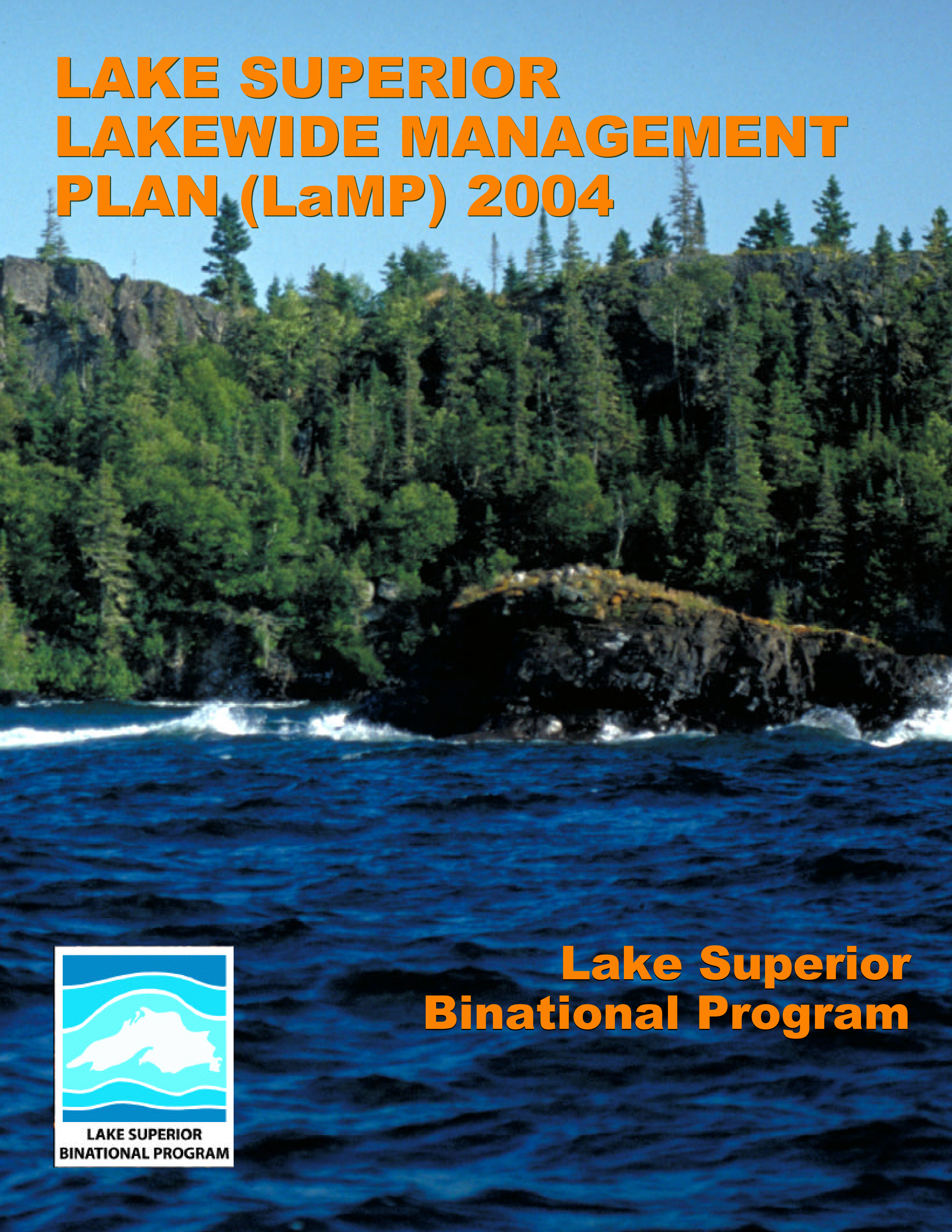
LAKE SUPERIOR LAKEWIDE MANAGEMENT PLAN (LaMP) 2004



Lake Superior Binational Program

LAKE SUPERIOR
BINATIONAL PROGRAM

Lake Superior Lakewide Management Plan (LaMP)

2004

Lake Superior Binational Program

This preface document replaces the LaMP 2000 preface.

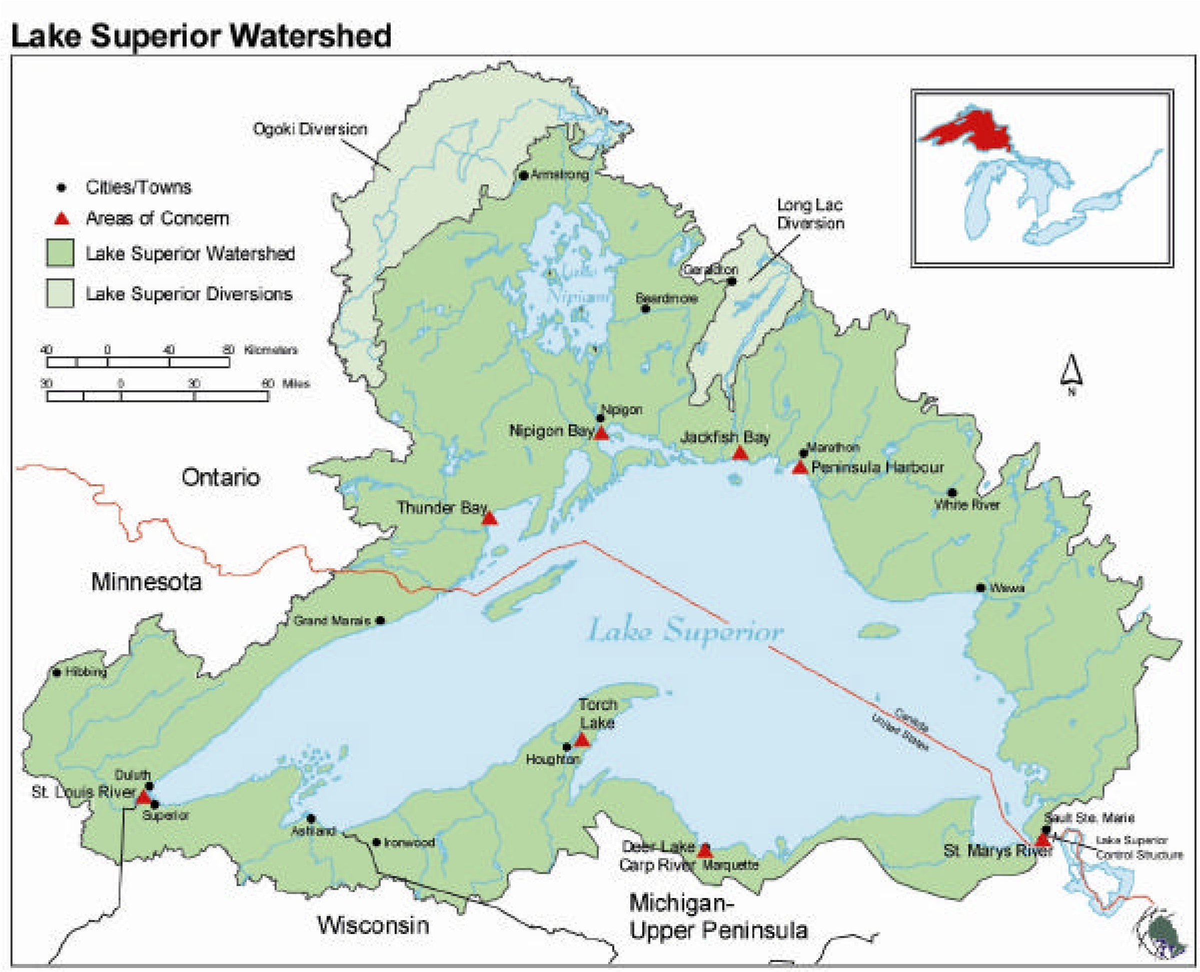
Preface
Lakewide Management Plans

One of the most significant environmental agreements in the history of the Great Lakes was put in place with the signing of the Great Lakes Water Quality Agreement of 1978 (GLWQA), between the United States and Canada. This historic Agreement committed the U.S. and Canada (the Parties) to address the water quality issues of the Great Lakes in a coordinated, joint fashion. The purpose of the Agreement was to “restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem” (IJC 1993).

In the revised GLWQA of 1978, as amended by Protocol signed November 18, 1987, the Parties agreed to develop and implement, in consultation with State and Provincial Governments, Lakewide Management Plans (LaMPs) for open lake waters and Remedial Action Plans (RAPs) for Areas of Concern (AOCs). The LaMPs are intended to identify the critical pollutants that affect the beneficial uses of the lakes and to develop strategies, recommendations, and policy options to restore these beneficial uses. Moreover, the Specific Objectives Supplement to Annex 1 of the GLWQA requires the development of Ecosystem Objectives for the Lakes as the state of knowledge permits. Annex 2 further indicates that the RAPs and LaMPs “shall embody a systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses....they are to serve as an important step toward virtual elimination of persistent toxic substances...”.

The Great Lakes Water Quality Agreement specifies that the LaMPs are to be completed in four stages. These stages are: 1) when problem definition has been completed; 2) when the schedule of load reductions has been determined; 3) when remedial measures are selected; and 4) when monitoring indicates that the contribution of the critical pollutants to impairment of beneficial uses has been eliminated. These stage descriptions suggest that the LaMPs are to focus solely on the impact of critical pollutants to the Lakes. However, the group of government agencies designing the LaMPs felt it was also necessary to address other equally important issues in the Lake basins. Therefore, the LaMPs go beyond the requirement of a LaMP for critical pollutants, and use an ecosystem approach, integrating environmental protection and natural resource management.

The Lake Superior LaMP is unique because of an additional agreement, announced in 1991, between the federal governments, states and province surrounding Lake Superior. Called the Binational Program to Restore and Protect the Lake Superior Basin, the program established a Zero Discharge Demonstration Program and a broader ecosystem approach. The Zero Discharge Demonstration was created in response to citizen and International Joint Commission recommendations to establish Lake Superior as a pilot for zero discharge. Annex 12 of the Great Lakes Water Quality Agreement notes that “the philosophy adopted for control of inputs of persistent toxic substances shall be zero discharge.”



The LaMP process has proven to be a resource intensive effort and has taken much longer than expected. In the interest of advancing the rehabilitation of the Great Lakes, and getting more information out to the public in a timely manner, the Binational Executive Committee (BEC) passed a resolution in 1999 to accelerate the LaMP effort. By accelerate, it was meant that there should be an emphasis on taking action and adopting a streamlined LaMP review and approval process. The LaMPs should treat problem identification, selection of remedial and regulatory measures, and implementation as a concurrent, integrated process rather than a sequential one. In the Lake Superior LaMP, Stages 1 and 2 were completed before the BEC decision and Stage 3 was integrated into LaMP 2000 as the critical chemicals chapter.

Consistent with the BEC resolution, the LaMP contains appropriate funded and proposed (non-funded) actions for restoration and protection to bring about actual improvement in the ecosystem. Actions include commitments by the Parties, governments and regulatory programs, as well as suggested voluntary actions that could be taken by non-governmental partners. LaMP 2002 reported on the success of those actions, and identified challenges remaining to achieve established goals and ecosystem objectives.

In the Lake Superior LaMP, Stages 1 and 2 were completed before the BEC decision and Stage 3 was integrated into LaMP 2000 as the critical chemicals chapter.

Furthermore, BEC suggested that the LaMPs be based on the current body of knowledge and state what remedial actions can be implemented now. It was recommended that a LaMP be produced for each Lake by April 2000, with updates every two years thereafter.

The concept of adaptive management is being applied to the LaMP process. An iterative approach is being taken with periodic refining based upon the lessons learned, successes, new information, and public input generated. The LaMP will adjust over time to address the most pertinent issues facing the Lake ecosystem.

Some parts of LaMP 2004 identify data gaps and next steps for LaMP 2006. LaMP 2004 is presented in a loose-leaf format with tabbed sections that can be inserted into a three-ringed binder. This format allows for easy updates, additions of new material, and removal of outdated information. The table which follows is a guide to updating your LaMP 2000 with the LaMP 2004 updates.

Lake Superior LaMP 2004 Guide to Changes

File name	Contents	How to Update your LaMP 2000 binder
LS Preface 2004	Preface/Executive Summary	Replaces LaMP 2000 Preface
LS Chapter 1 2004	Introduction and Purpose of the Lake Superior Lakewide Management Plan	Replaces LaMP 2000 Chapter 1
LS Chapter 2 2004	Public Outreach and Education, Report from the Forum	Replaces LaMP 2000 Chapter 2
LS Chapter 3 2000	Ecosystem Objectives	No changes
LS Chapter 4 Update 2004	Lake Superior Critical Pollutants Progress Report	Insert at beginning of Chapter 4
LS Chapter 4 2000	Lake Superior Critical Pollutants	No changes (This chapter will be updated in 2005 for inclusion in the 2006 report)
LS Chapter 5 Update 2004	Human Health Information	Insert at beginning of Chapter 5
LS Chapter 5 2000	Human Health	No changes
LS Chapter 6 Update 2004	Update/Progress Report on Consolidated Ecosystem Chapters (6, 7, 8, 10); Habitat Progress Report	Insert at beginning of Chapter 6
LS Chapter 6 Table of Contents 2000	Status of Habitat in the Lake Superior Basin[Note: Chapter 6 is in 5 files]	No changes (This chapter will be updated in 2004, as part of the new consolidated ecosystem chapter, for inclusion in the 2006 report.)
LS Chapter 6a/b/c 2000 and Addendums		
LS chapter 7 2000	Terrestrial Wildlife Communities	Insert at beginning of Chapter 7

File name	Contents	How to Update your LaMP 2000 binder
LS Chapter 8 update 2004	The Aquatic Communities Progress Report	Insert at beginning of Chapter 8
LS Chapter 8 2000	The Aquatic Community Part 1: Fish and Their Habitat	No changes (This chapter will be updated in 2004, as part of the new consolidated ecosystem chapter, for inclusion in the 2006 report.)
LS Chapter 9 2004	Developing Sustainability in the Lake Superior Basin	Replaces LaMP 2000 Chapter 9
LS Chapter 10 2000	Aquatic Nuisance Species	No changes (This chapter will be updated in 2004, as part of the new consolidated ecosystem chapter, for inclusion in the 2006 report.)
(No File – LaMP 2000 Chapter removed)	Atmospheric Deposition of Pollutants of Concern	Remove LaMP 2000 chapter 11 (This is now being addressed by the Great Lakes Binational Toxics Strategy – see long rage transport challenge www.binational.net). See also LaMP 2002 for update.
LS Appendix A 2004	Lake Superior Areas of Concern/Remedial Action Plan Summary Matrix	Replaces LaMP 2000 Appendix A
LS Appendix B 2000	Total Maximum Daily Load (TMDL) Development Strategy for Lake Superior	No Change
LS Glossary 2000	Glossary	No change
LS Acronyms 2000	Acronyms and Abbreviations	No change
LS errata 2000	Errata Sheet - 4/18/00	No change

Acknowledgements
Lake Superior Lakewide Management Plan

The Lake Superior Lakewide Management Plan 2004 was prepared by the Lake Superior Binational Program's Superior Work Group with input from various other agencies and organizations including the Lake Superior Binational Forum. We would like to thank the committees of the Superior Workgroup for their efforts in completing this document.

Member agencies of the Lake Superior Binational Program are:

1854 Authority
Agency for Toxic Substances and Disease Registry
Bad River Band of Lake Superior Chippewa
Chippewa-Ottawa Treaty Fishery Management Authority
Environment Canada
Fisheries and Oceans Canada
Fond du Lac Band of Lake Superior Chippewa
Fort William First Nation
Grand Portage Band of Lake Superior Chippewa
Great Lakes Indian Fish and Wildlife Commission
Health Canada
Keweenaw Bay Indian Community
Michigan Department of Environmental Quality
Michigan Department of Natural Resources
Minnesota Department of Natural Resources
Minnesota Department of Health
Minnesota Pollution Control Agency
Ontario Ministry of Natural Resources
Ontario Ministry of the Environment
Parks Canada
Red Cliff Band of Lake Superior Chippewa
U.S. Environmental Protection Agency
U.S. Fish and Wildlife Service
U.S. Forest Service
U.S. Geological Survey - Biological Resources Division
U.S. National Park Service
Wisconsin Department of Natural Resources

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Executive Summary

Background

One of the most significant environmental agreements in the history of the Great Lakes was put in place with the signing of the Great Lakes Water Quality Agreement of 1978 (GLWQA), between the United States and Canada. This historic Agreement committed the U.S. and Canada (the Parties) to address the water quality issues of the Great Lakes in a coordinated, joint fashion. The purpose of the Agreement was to "restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem" (IJC 1993). The 1987 amendment to the GLWQA required the development of Lakewide Management Plans (LaMPs) which "shall embody a systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses...they are to serve as an important step toward virtual elimination of persistent toxic substances..." This document represents the current LaMP for Lake Superior.

The Great Lakes Water Quality Agreement specifies that the LaMPs are to be completed in four stages. However, under a streamlined LaMP review and approval process, the LaMPs now treat problem identification, selection of remedial and regulatory measures, and implementation as a concurrent, integrated process rather than a sequential or staged one. In the Lake Superior LaMP, Stages 1 and 2 for critical chemicals were completed before the decision was made to integrate. Stage 3 was merged into LaMP 2000 as the critical chemicals chapter. To date, no other LaMP has a load reduction schedule for critical pollutants as required by the Agreement.

In addition, the LaMPs go beyond the requirement of a LaMP for critical pollutants and use an ecosystem approach, which integrates environmental protection and natural resource management. LaMP progress is now reported every two years. Adaptive management is used to allow the process to change as needed by building upon successes, accepting new information and drawing from public involvement and input. The LaMP therefore, can be adjusted over time to respond to the most pertinent issues facing the lake ecosystem. Additional details on this can be found in Chapter 1.

The Lake Superior LaMP is unique because of an additional agreement between the federal governments, states and province surrounding Lake Superior. Announced in 1991, the agreement, called the "Binational Program to Restore and Protect the Lake Superior Basin," established a Zero Discharge Demonstration Program and a broader ecosystem approach.

The LaMP/Lake Superior Binational Program contains appropriate funded and proposed (non-funded) actions for restoration and protection to bring about actual improvement in the ecosystem. Actions include commitments by the Parties, governments and regulatory programs, as well as suggested voluntary actions that could be taken by non-governmental partners. LaMP 2000 identified these actions in six ecosystem themes: critical pollutants, aquatic communities, terrestrial wildlife communities, habitat, human health and developing sustainability. A LaMP update in 2002 reported on the success of those actions, and identified challenges remaining to achieve established goals and ecosystem objectives.

LaMP 2004

LaMP 2004 builds on the LaMP 2000 document; it incorporates all the LaMP 2000 chapters unless the chapters have been updated or rewritten. For example, the Critical Pollutants chapter remains the same, although a progress report detailing accomplishments and progress from 2002 to 2004 is included. Where the chapters remain the same as in LaMP 2000, a progress report presents an accomplishment summary of the 1) actions completed or underway to improve the lake, 2) challenges, and 3) next steps or changes to ongoing management actions.

Chapter 9, "Developing Sustainability," has been revised to incorporate public input. A new ecosystem chapter, consolidating and updating information contained in chapters 6, 7, 8 and 10 of LaMP 2000, will be finalized in 2004 and incorporated into LaMP 2006. Chapter 4 (Critical Pollutants) similarly will be revised for LaMP 2006.

LaMP 2004 identifies data gaps and next steps for LaMP 2006. LaMP 2004 is available in CD-ROM format, and is designed to be printed in a loose-leaf format with general tabbed sections that can be inserted into a three-ringed binder. This format allows for easy updates, additions of new material and removal of outdated information.

A detailed guide to changes and instructions on how to update the LaMP 2000 document is contained in the Preface.

This Lakewide Management Plan Report 2004 is not intended to be extensively circulated to the public; the agencies plan to produce a separate document to inform the public on Binational Program activities. Citizens of the basin, as partners and stakeholders in the Binational Program, are strongly encouraged to become actively involved. The Lake Superior Binational Public Forum can be reached at 1-888-301-LAKE (1-888-301-5253).

Accomplishment and Next Steps Highlights 2002 to 2004

The Lake Superior Binational Forum

The Lake Superior Binational Forum, the primary public body associated with the agencies responsible for carrying out the Binational Program, has been key to establishing an effective multi-stakeholder process. The Forum has held many workshops over the years for the purpose of acquiring necessary background information to help develop recommendations and proposals for sustainable development, human health and reducing the Lake Superior nine critical pollutants. The Forum has also published many documents on key issues relating to the LaMP.

Accomplishments include:

- initiating joint projects on chemical reductions, outreach and stewardship;
- organizing elected officials in two states, four cities, and one tribe to sign a proclamation declaring the third Sunday in July 2003 as Lake Superior Day; and
- holding workshops on household garbage burning, mercury, and riparian areas.

- The mercury workshop in Thunder Bay in June 2003 featured speakers on human health issues, the mercury inventory of Lake Superior sources, and on a variety of mercury reduction activities, including those in the municipal, industrial, and commercial sectors.

Next Steps include:

- establish Lake Superior stewardship and awards program;
- expand and celebrate Lake Superior Day;
- expand outreach on residential garbage burning;
- prepare and publish a newspaper insert; and
- continue public input sessions at Forum meetings.

Superior Workgroup

The activities below represent accomplishments by the various committees of the Lake Superior Workgroup.

Critical Pollutants

Accomplishments include:

- Mercury pollution prevention and awareness (e.g. progress in dental sector, collection of thermostats, fluorescent tubes, auto switches, thermometers, and button batteries);
- Residential garbage burning awareness campaigns;
- Progress on contaminated sediment assessment and cleanup;
- Declines in contaminants in Herring Gull eggs and sportfish; and
- Declines in number and geographic extent of sportfish consumption restrictions.

Next Steps include:

- Continued implementation of LaMP 2000 priority activities;
- Preparation of a 2005 report to review milestones and update reduction strategies;
- Continuation of sediment remediation in both countries; and
- Continuation of Stormwater Management to prevent pollutant loadings.

Habitat

Accomplishments include:

- Implementing watershed management and forest stewardship projects;
- Progress to establish a National Marine Conservation Area;
- Implementing monitoring, assessment and inventory projects; and
- Implementing habitat restoration projects including fish passage culvert, dam removal, stream restoration, riparian improvement and wetland restoration.

Next Steps include:

- Update information in the public kiosk network;

- Consolidate LaMP ecosystem chapters by Summer 2004;
- Develop consensus on status and trends of habitat conditions; and
- Develop recommendations for the protection and restoration of ecological functions.

Terrestrial Wildlife

Accomplishments include:

- Monitoring and inventory of herptiles, native and rare plants, peregrine falcons, bald eagles, spruce beetles, lynx, wolf, beaver, otter, deer, and breeding birds;
- Initiation of development and evaluation of monitoring protocols;
- Initiation of a wood turtle recovery plan;
- Initiation of an invasive species framework, planning and treatment;
- Completion of herptile and soil invertebrate indicator projects, including a herptile workshop; and
- Completion of inventories of recovery plans and species at risk.

Next Steps include:

- Development and implementation of a biological community-based monitoring program;
- Identify method to monitor land use change;
- Refinement of herptile monitoring plans; and
- Development of inventory and control projects for invasive species.

Aquatic Communities

Accomplishments include:

- Completion of a hydro acoustic survey;
- Restoring or rehabilitating critical habitat for brook trout and other fish in 14 tributaries;
- Initiation of strategy on walleye rehabilitation;
- Establishment of lake-wide sturgeon rehabilitation effort;
- Development of GIS database related to timber cutting cycles, tree planting programs, brook trout habitat, buffers, and reduction of erosion and sedimentation in Lake Superior tributaries;
- Developing environmental objectives to support Lake Superior’s Fish Community Objectives;
- Continuation of fish surveillance surveys to document range expansion of ruffe and detect other Aquatic Nuisance Species (in 2003, round goby and white perch were discovered and confirmed in Thunder Bay Harbour, Ontario); and
- Continuation of sea lamprey management and control activities.

Next Steps include:

- Continuation of acoustic projects on prey fish monitoring and critical shallow water habitat quantification;
- Continuation of work on rehabilitation of coastal brook trout, walleye and sturgeon populations;

- Establishment of environmental objectives for Lake Superior;
- Establishment of a lower trophic level monitoring program for Lake Superior;
- Reporting on the status of lake herring;
- Identifying inland aquatic systems in need of rehabilitation or protection; and
- Examining feasibility of using sea lamprey pheromones as an additional tool for control and management of sea lamprey.

Human Health

Accomplishments include:
- Participation in the establishment of a Great Lakes basin-wide Human Health Network.

Next Steps include:
- Continue seeking membership to the Network;
- Help the Lakes set human health priorities and action steps; and
- Outreach on human health concerns and risks to Great Lakes human health officials.

Sustainability

Accomplishments include:
- Initiating the Community Awareness Review and Development (CARD) project; and
- Expanding the baseline indicators project so as to develop land-use indicators.

Next Steps include:
- Continuation of the CARD project;
- Initiation of the Lake Superior Stewardship/Leadership School;
- Promoting water conservation, marketing waste reduction and energy efficiency, understanding sprawl; and
- Promoting sustainability workshops.

Challenges of the Binational Program

In general, the next steps for the Binational Program are to continue to implement projects identified in LaMP 2000, advocate the benefits to decision makers and the public to ensure continued support for toxic chemical reduction activities, continue communication and outreach activities that will achieve measurable progress toward the Binational Program goals, prepare various internal and public reports, including LaMP 2006, and seek additional funding. Future accomplishments will be dependent upon commitments by governments, NGOs and individuals to support the science, resource management and legislative activities that will protect and restore the basin.

Habitat challenges include ongoing support and maintenance of the geographic database and projects associated with the Lake Superior Decision Support System, information gaps on the status and trends of habitat conditions, developing management recommendations, participation on the Habitat Committee by members of agencies and organizations, and educating the public on important habitat and ecological resources in the Lake Superior basin by expanding the use of interactive information kiosks.

Integrative work is necessary to inventory, monitor and manage terrestrial wildlife. The development and implementation of a biological community-based monitoring program remains a long-term goal. Plans for herptile monitoring will be refined and work on medium sized carnivores (the remaining suite of species to evaluate) will begin. Throughout the LaMP process improper land use has consistently been identified as an important contributor to environmental impairment. A method by which land use change can be monitored over time and used to track progress towards LaMP implementation is needed.

Stresses and their impacts on aquatic ecosystems continue to be a challenge in the Lake Superior basin. Challenges include establishing agency support for and maintenance of long-term biota and habitat monitoring programs; ensuring the maintenance of healthy aquatic communities on rivers with, and those identified for hydro power development; completing around the lake mapping of nearshore fish habitat; preventing invasion and transport of non native species; funding continued monitoring efforts for invasive species and fish community changes and status; protecting critical lake and tributary habitats; and expanding knowledge of aquatic systems and the human induced perturbations that may have changed or limited their productivity.

Even though the idea of sustainability has long provided a foundation for the Lake Superior Binational Program, it is difficult to decide how we should go about facilitating sustainable practices on the ground. To promote practices that provide for sustainable outcomes requires consideration of a variety of issues that go beyond the prevention of pollution. To produce a truly sustainable society, we must grapple with issues that are more general in scope than those associated with other aspects of the LaMP. Though progress has been made, we are still a long way from promoting a full range of social and economic initiatives that will make for a sustainable future.

Chapter 1

Introduction and Purpose of the Lake Superior Lakewide Management Plan

This document replaces LaMP 2000 Chapter 1.

Lake Superior shoreline early fall, Lake Superior, Minnesota
Photograph by Wisconsin Division of Tourism

Lake Superior Lakewide Management Plan
2004

Chapter 1 Contents

Chapter 1
Introduction and Purpose of the Lake Superior Lakewide Management Plan

1.0 INTRODUCTION

The Lake Superior basin is one of the most pristine and unique ecosystems in North America. Containing the largest surface area of any freshwater lake in the world, Lake Superior has some of the most breathtaking scenery in the Great Lakes and serves as a backdrop to a wide range of recreational and outdoor activities enjoyed by people from all over the world. Sparsely populated even today, Lake Superior has not experienced the same level of development, urbanization, or pollution as the other Great Lakes. Recognizing this unique and invaluable resource, the federal, state and provincial, and U.S. tribal governments; First Nations; environmental groups; industry; and the public have taken steps to protect this great legacy for generations to come. This shared partnership has served as a model the world over for cooperative binational resource management.

The Great Lakes Water Quality Agreement (GLWQA) between the U.S. and Canada commits the two countries (the Parties) to address the water quality issues of the Great Lakes in a coordinated fashion. Annex 2 of the GLWQA provides a framework for the reduction of critical pollutants as they relate to impaired beneficial uses of open lake waters. In undertaking Lakewide Management Plans (LaMP), the Parties agree to build upon cooperative efforts with state and provincial governments and to ensure that the public is consulted. The Parties, partner agencies, and Tribal/First Nations also recognize the need to conduct lakewide adaptive management using an ecosystem approach which addresses human health, habitat, terrestrial wildlife communities, aquatic communities, and developing sustainability.

1.1 THE LAKE SUPERIOR BINATIONAL PROGRAM

In 1990, the fifth biennial report of the International Joint Commission (IJC) to the U.S. and Canadian governments recommended that Lake Superior be designated as a demonstration area where “no point source discharge of any persistent toxic substance will be permitted.” In response, on September 30, 1991, the federal governments of Canada and the U.S., the Province of Ontario, and the States of Michigan, Minnesota, and Wisconsin announced a **Binational Program to Restore and Protect Lake Superior**. Known as the Lake Superior Binational Program (LSBP), the Program identifies two major areas of activity:

- A Zero Discharge Demonstration Project
- The Broader Program

The LSBP also recognizes that public participation is an important part of the program.

The Zero Discharge Demonstration Program (ZDDP) established Lake Superior as a demonstration project to achieve zero discharge and zero emission of nine toxic, persistent, and bioaccumulative chemicals: mercury, total polychlorinated biphenyls (PCBs), dieldrin/aldrin, chlordane, DDT, toxaphene, 2,3,7,8-TCDD (dioxin), hexachlorobenzene (HCB) and octachlorostyrene (OCS). Voluntary pollution prevention is the preferred approach to achieving reduction goals, but enhanced controls and regulations might be necessary to achieve zero discharge.

The Broader Program recognizes that zero discharge of persistent toxic substances alone will not be sufficient to restore and protect Lake Superior. The Broader Program focuses on the coordination needed among the many resource and environmental agencies.

Public Involvement is critical to the success of the Binational Program. The LSBP highlights the importance of the partnership approach to achieve specified common goals. The Program encourages the commitment of all partners to develop new and innovative approaches to ecosystem management. The citizens of the basin are partners and stakeholders in the Binational Program.

LSBP Organization

Lake Superior Task Force

The Task Force consists of senior Canada and U.S. federal, provincial, and state representatives and tribal members who make management decisions related to Lake Superior. The Task Force serves as a steering committee and is responsible for program direction.

Superior Work Group

The Work Group is comprised of Canadian and U.S. technical experts who represent various agencies and organizations that manage Lake Superior water and other resources. The Work Group reports to the Task Force. The Work Group is comprised of a number of committees, currently including: critical pollutants, habitat, aquatic communities, terrestrial wildlife communities, developing sustainability, and public involvement. These committees address pollution prevention and reduction, habitat issues, aquatic and terrestrial community diversity and sustainability, special designations, ecosystem integrity and monitoring, human use and health issues, and public communication and involvement.

Lake Superior Binational Forum

The Forum is a group of 24 Lake Superior citizen volunteers who make recommendations to the governments, consult with the broader public, and carry out joint LaMP implementation projects. Forum members bring perspectives from a variety of community sectors including business, environmental groups, academia and industry. The vision statement endorsed in 1992 by the Forum is also a philosophical backdrop for the Binational Program.

A VISION FOR LAKE SUPERIOR

As citizens of Lake Superior, we believe...

that water is life and the quality of water determines the quality of life.

We seek a Lake Superior watershed *...*

that is a clean, safe environment where diverse life forms exist in harmony; where the environment can support and sustain economic development and where the citizens are committed to regional cooperation and personal philosophy of stewardship;

that is free of toxic substances that threaten fish, wildlife and human health; where people can drink the water or eat the fish anywhere in the lake without restrictions;

where wild shorelines and islands are maintained and where development is well planned, visually pleasing, biologically sound, and conducted in an environmentally benign manner;

which recognizes that environmental integrity provides the foundation for a healthy economy and that the ingenuity which results from clean, innovative and preventive management and technology can provide for economic transformation of the region;

where citizens accept the personal responsibility and challenge of pollution prevention in their own lives and lifestyles and are committed to moving from a consumer society to a conserver society; and

where there is greater cooperation, leadership and responsibility among citizens of the basin for defining long-term policies and procedures which will protect the quality and supply of water in Lake Superior for future generations.

We believe that by effectively addressing the issues of multiple resource management in Lake Superior, the world's largest lake can serve as a worldwide model for resource management.

Endorsed by the Lake Superior Binational Forum on January 31, 1992
as an expression of the hearts and minds of all of us.

This vision statement expresses the commitment and desire of members of the Lake Superior community to foster a healthy, clean, and safe Lake Superior ecosystem. It reflects the diverse pathways and mechanisms by which humans and nature interact within land and water ecosystems, and challenges the inhabitants of the Lake Superior watershed to accept personal responsibility for protecting the Lake and the landscape that sustains it. The vision statement specifies broad, powerful objectives for the Lake Superior ecosystem, in plain language.

1.1.1 LaMP Documents Produced To Date

Historically, formal LaMP "stages" were to be submitted to the IJC when a key stage of work was completed, in accordance with the framework outlined in Annex 2 of the 1987 amendments to the GLWQA:

- Stage 1: When problem definition is complete and critical pollutants are identified;
- Stage 2: When chemical load reduction schedules are completed;
- Stage 3: When remedial measures have been selected: and
- Stage 4: When monitoring indicates that the contribution of critical pollutants to impaired beneficial uses has been eliminated.

LaMP Stages 1, 2 and 3 have been completed for the chemical portion of the Lake Superior LaMP.

The Lake Superior Stage 1 LaMP which was submitted to the IJC in September 1995, used environmental data to identify 22 critical pollutants that 1) impaired or were likely to impair beneficial uses in the Lake, 2) were likely to affect human health or wildlife because they exceed chemical yardsticks, or 3) impair Lake ecosystem objectives. The Stage 1 LaMP summarizes all known data on critical pollutant loadings from point sources throughout the Lake Superior basin.

The Stage 2 LaMP, which was submitted to the IJC in July 1999, sets remediation goals or load reduction schedules for the nine virtual elimination pollutants identified in the Stage 1 LaMP. The Lake Superior Binational Forum stakeholders group submitted pollutant reduction recommendations, which were public and agency reviewed, edited and formed the basis for the final targets set in the Stage 2 LaMP. In Stage 2, the critical pollutants were placed into management categories that reflect pollutant impacts, tendency to bioaccumulate, and occurrence at toxic levels.

The Stage 3 LaMP requirements under the GLWQA, captured in chapter 4 of LaMP 2000, selects pollutant load reduction strategies and remedial actions with respect to the nine virtual elimination pollutants: mercury, PCBs, dieldrin/aldrin, chlordane, DDT, toxaphene, dioxin, hexachlorobenezene, and octachlorostyrene.

In addition to staged LaMP reporting on the ZDDP, work proceeded in two areas between 1991 and 1998: habitat and non-regulatory special designations. In the program area of habitat, agencies developed ecological criteria for important Lake Superior habitat, set up a database for habitat sites, prepared a comprehensive GIS-based map of important habitat sites and areas, and examined the impact from major dischargers on habitat. In the program area of sustainability, criteria for non-regulatory special designations were developed. One outcome of this work was the Parks Canada project to designate a

National Marine Conservation Area (NMCA) for one third of the Canadian waters of Lake Superior. It is expected that the NMCA will be formally established in 2004.

1.1.2 Ecosystem Components

While the initial focus of the LaMP work was on the reduction of critical pollutants, establishing the zero discharge demonstration program, and a broader program that advanced our understanding of habitat and landscapes, work has been carried out in other areas as well. The partner agencies have developed LaMP documents for a number of ecosystem themes, including aquatic communities, terrestrial wildlife communities, habitat, human health, and developing sustainability. The work in these themes was released for the first time for public comment and review in LaMP 2000.

Adopting an ecosystem approach has initiated a shift from a narrow perspective of managing environmental media (water, air, and soil) or a single resource (e.g., fish or trees) to a broader perspective that focuses on managing human uses and abuses of watersheds or bioregions and that comprehensively addresses all environmental media and resources within the context of a living system. The Lake Superior LaMP is guided by a set of ecosystem objectives and indicators to judge progress. Published as a discussion paper in 1995, the document ***Ecosystem Principles and Objectives, Indicators, and Targets for Lake Superior*** describes extensive ecosystem objectives and sub-objectives. These objectives have been refined and updated since the document's original release and are described in abbreviated form below:

1. <u>General Objective</u> - Human activity in the Lake Superior basin should be consistent with *A Vision for Lake Superior*. Future development of the basin should protect and restore the beneficial uses as described in Annex 2 of the GLWQA.

2. <u>Chemical Contaminants Objective</u> - Levels of persistent, bioaccumulative, and toxic chemicals should not impair beneficial uses of the natural resources of the Lake Superior basin. Levels of chemical contaminants which are persistent, bioaccumulative, and toxic should ultimately be virtually eliminated in the air, water and sediment in the Lake Superior basin. A zero discharge demonstration program is the primary means for achieving reductions of in-basin sources of contaminants.

3. <u>Aquatic Communities Objective</u> - Lake Superior should sustain diverse, healthy, reproducing and self-regulating aquatic communities closely representative of historical conditions.

4. <u>Terrestrial Wildlife Objective</u> - The Lake Superior ecosystem should support a diverse, healthy and sustainable wildlife community in the Lake Superior Basin.

5. <u>Habitat Objective</u> - To protect, maintain and restore high-quality habitat sites in the Lake Superior basin and the ecosystem processes that sustain them. Land and water

uses should be designed and located compatible with the protective and productive ecosystem functions provided by these natural landscape features.

6. Human Health Objective - The goal of the Lake Superior LaMP Human Health Chapter is to fulfill the human health requirements of the GLWQA, including: defining the threat to human health and describing the potential adverse human health effects arising from exposure to critical pollutants and other contaminants (including microbial contaminants) found in the Lake Superior basin, addressing current and emerging human health issues of relevance to the LaMP, and identifying implementation strategies currently being undertaken to protect human health and suggesting additional implementation strategies that would enhance the protection of human health.

7. Developing Sustainability - Human use of the Lake Superior ecosystem should be consistent with the highest social and scientific standards for sustainable use, and should not degrade it, nor any adjacent ecosystems. Use of the Basin's natural resources should be consistent with their capability to sustain the ecosystems' identity and functions, should not risk the socioeconomic and cultural foundations of any citizens, nor deny any generation the benefits of a healthy, natural Lake Superior ecosystem. The obligation of local communities to determine their future should be incorporated in any polices directed at the management of natural and social resources in the Basin.

The Ecosystem Principles and Objectives document also contained a set of preliminary indicators and targets. Proposed objectives, and "best bet" indicators to monitor progress on these objectives, were proposed and reviewed at a workshop in 1999.

In the ***LaMP 2002 update***, it was noted that a comprehensive set of ecosystem targets needed to be developed to guide management actions over the long term. In keeping with the public's recommendation of integrating the habitat, terrestrial wildlife, and aquatic committees, the three committees started work on developing a set of ecosystem goals. The ecosystem goals being developed are for (1) uplands, (2) wetlands, (3) tributaries and inland lakes, (4) open lake, and (5) basin-wide considerations. Specific draft examples were provided as follows:

- Uplands: Provide sources of native plants and seeds in an ecologically appropriate manner for use in restoration projects by 2006. Write and implement ecologically based integrated watershed management plans for all watersheds in the Lake Superior basin by 2025.
- Wetlands: Create and distribute a spatial database of coastal wetlands organized by type and condition and identify areas where restoration can occur by 2006. Restore 25 percent of the degraded wetland acreage in the Lake Superior basin by 2010.
- Tributaries and Inland Lakes: Restore or protect 25 percent of the riparian conifer forest acreage by 2010. Rehabilitate 50 percent of 64 tributaries to Lake Superior

in order to achieve Fish Community Objectives for indigenous lake trout, brook trout, walleye, and lake sturgeon. Rehabilitate the remaining tributaries by 2050.

- Open Lake: By 2006, implement lake-wide acoustics monitoring to measure the abundance and species composition of the pelagic fish community. By 2010, quantify and describe the bottom substrates in 50 percent of Lake Superior waters that are less than 30 meters deep, and by 2015, quantify and describe the bottom substrates in the remaining waters that are less than 30 meters deep.
- Basin-Wide: Develop and establish a unified, binational, GIS-based database that includes the most current and functioning basin-wide decision support models needed for ecosystem and watershed management and methods for providing data access and distribution by 2006. Complete an inventory and control plan for existing priority exotic species in the Lake Superior basin by 2010. By 2020, transfer knowledge of best management practices and LaMP goals to all affected units of government (townships, counties, and municipalities) within the 15 watersheds of Lake Superior.

1.2 LaMP ACCELERATION AND THE LaMP DOCUMENT

1.2.1 What is LaMP 2004?

In May 1999, the Great Lakes States Environmental Directors issued a challenge to the U.S. Environmental Protection Agency (U.S. EPA) that all LaMP documents were to be completed by Earth Day 2000. This challenge was accepted at a meeting of the Binational Executive Committee (BEC), which is composed of senior managers from the U.S. EPA, Environment Canada, the Great Lakes states, the Province of Ontario, and several tribes. A resolution was adopted by the BEC that calls for the completion by April 2000 of a "LaMP 2000" document which would reflect the state of the knowledge and progress of the LaMPs at that time (See Addendum 1-A to this chapter).

LaMPs were published in 2000 and progress reports were released in the spring of 2002. Analysis by various LaMP work groups identified a need to refine the LaMP reporting process, particularly with regard to the time, effort, and resources needed to produce the documents. Greater emphasis needed to be placed on implementation and partnerships to protect each Lake basin. To that end, the BEC endorsed an approach to reporting in 2003 that strikes a balance between consistency among LaMPs and individual LaMP needs, while minimizing reporting efforts. LaMP teams endeavor to spend at least 80% of their time on LaMP implementation, and a maximum of 20% on reporting.

The LaMP document serves several purposes. First, it summarizes the technical research and scientific study of the Lake Superior ecosystem. Second, it represents a framework and road map for guiding and supporting priority actions and/or additional research in the basin. Third, the document presents actual pollution prevention, restoration, and other actions that governments, industries, tribes, and other stakeholders can take to achieve the overall goals and visions of the LaMP. Finally, the document will serve as a strategic plan to help achieve sustainability in the basin ecosystem.

While the Lake Superior LaMP 2002 document was a summary progress report, this 2004 document is the first of what will be biennial updates, with the latest available scientific and technical information incorporated into the existing LaMP document. The primary audience for this report is the Parties and their partners who are charged with lakewide management. Secondarily, this report will also be used to meet reporting requirements to the IJC.

1.2.2 Action/Projects Matrices

Each of the LaMP chemical and ecosystem components contain specific actions and projects that will be taken to help achieve the goals and objectives of the LaMP. Some of these actions already have commitments and funding by various state, federal, provincial or other entities. Other actions are categorized as high priority but still need agency commitment or funding. These actions can be found in the respective chapters in the LaMP document.

1.3 RELATIONSHIP OF THE LaMP TO OTHER INITIATIVES AND EFFORTS

1.3.1 Remedial Action Plans for Areas of Concern

The GLWQA amendments of 1987 also called for the development of Remedial Action Plans (RAP) for designated Areas of Concern. The primary goal of the RAPs is to restore impaired “beneficial uses,” both ecological and cultural, as identified in Annex 2 of the GLWQA amendments, in degraded areas within the basin. The GLWQA amendments directed the two federal governments to cooperate with state and provincial governments to develop and implement RAPs for each AOC. In the Great Lakes basin, 43 AOCs have been identified by the U.S. and Canadian governments, 26 in U.S. waters, and 17 in Canadian waters (five are shared between the U.S. and Canada on connecting river systems).

Collingwood Harbour and Severn Sound, in Ontario, are the first two of these 43 sites to be de-listed. There are eight AOCs in the Lake Superior Basin, four in Canada, three in the U.S., and one shared between the two countries along the St. Marys River. A matrix summarizing the current status of the Lake Superior RAPs may be found in **Appendix A** of the LaMP.

The RAPs and LaMPs are similar in that they both use an ecosystem approach to assessing and remediating environmental degradation, consider the 14 beneficial use impairments outlined in Annex 2, and rely on a structured public involvement process. RAPs, however, encompass a much smaller geographic area, concentrating on an embayment, a single watershed or stretch of a river. The main focus of a RAP is on environmental degradation in that specific area, and remediating the beneficial use impairments locally. Most of the Lake Superior RAPs have had active local Public Advisory Committees (PACs), with stakeholders in some cases undertaking local remediation projects. In most AOCs, the beneficial use impairment (e.g. habitat loss) can be related or connected to local activities. On the other hand, some fish advisories are attributable to the lakewide concentrations of persistent, bioaccumulative toxic chemicals.

Forging a strong relationship between the LaMPs and the RAPs is important to the success of both efforts. The AOCs can, in many cases, serve as point source discharges to the lake as a whole. Improvements in the AOCs will therefore, eventually help to improve the entire lake. Much of the expertise about the use impairments and possible remedial efforts reside at the local level, cooperation between the two efforts is essential in order for the LaMPs to remove lakewide impairments.

1.3.2 Great Lakes Binational Toxics Strategy

Signed between the U.S. and Canada in 1997, the Great Lakes Binational Toxics Strategy (GLBTS) helps provide an overall coordinating effort across the lakes to reduce and virtually eliminate persistent toxic substances in the Great Lakes basin. The Binational Toxics Strategy provides a framework for actions to reduce or eliminate persistent toxic substances and establishes reduction challenges in the time frame 1997 to 2006 for twelve Level 1 persistent toxic substances including mercury and PCBs.

This effort is critical to the toxic reduction efforts of the Lake Superior LaMP for several reasons. First, the GLBTS can work in the national and international arena to address out-of-basin air deposition sources of toxic substances, an increasingly important source of inputs to the Lake. Second, it can help coordinate ongoing toxic reduction efforts across the basin, disseminating critical information on these successful projects. Also, because the GLBTS effort is closely coordinated with the U.S. national Persistent, Bioaccumulative and Toxic Chemical Initiative at U.S.EPA headquarters, the GLBTS can disseminate the most current national and international scientific information on the Lake Superior critical pollutants. Finally, the ambitious reduction time frames and schedules for virtual elimination of critical pollutants at the basin-wide and national level can help support similar reduction efforts in Lake Superior.

The GLBTS has attained reduction goals for nine of its Level I Persistent Toxic Substances. By 2006, the GLBTS expects to meet four additional reduction targets and be well advanced toward meeting the reduction goals for the remaining substances.

There are positive signs of progress in the Great Lakes. Canada has exceeded its 90% challenge reduction in the use, generation and release of alkyl-lead and the United States has met the binational challenge of confirming no-use of alkyl-lead in automotive gasoline. Canada has also met its Level I pesticide challenge that there is no longer use or release from sources that enter the Great Lakes basin of five bioaccumulative pesticides (chlordane, aldrin/dieldrin, DDT, mirex, and toxaphene). The GLBTS has also confirmed that Ontario has destroyed 85% of its high level PCBs, achieved a reduction in dioxin and furan emissions by 79% and recorded a decrease in mercury emissions into the Great Lakes basin by 83%.

1.3.3 U.S. Great Lakes Strategy

On April 2, 2002, the U.S. Policy Committee released the Great Lakes Strategy to advance Great Lakes protection and restoration efforts. The U.S. Policy Committee, a forum of senior-level representatives from the Federal, State, and Tribal agencies responsible for environmental and natural resources management of the Great Lakes, designed the strategy to help coordinate and streamline efforts of the many governmental partners involved with protecting the Great Lakes. The Strategy was developed with the consultation of the Great Lakes public. Workshops were held in Duluth, Chicago, Detroit, and Niagara Falls to solicit comments from local governments, industry, non-governmental environmental organizations, and the general public.

The Strategy focuses on multi-Lake and basin-wide environmental issues and establishes common goals that the governmental partners will work toward. It supports existing efforts underway, including Lakewide Management Plans and Remedial Action Plans for Areas of Concern, by addressing issues that are beyond the scope of these programs and helping integrate them into an overall basinwide context. It also advances the implementation of the United States' responsibilities under the Great Lakes Water Quality Agreement of 1987. The Strategy sets forth specific objectives and actions that will reduce contaminants, restore habitat, and protect the living resources of the basin.

The U.S. Policy Committee is currently implementing the Strategy and tracking progress on a yearly cycle. Management priorities and corrective actions are identified at biennial U.S. Policy Committee meetings and implemented by participating agencies.

ADDENDUM 1-A

BINATIONAL EXECUTIVE COMMITTEE CONSENSUS POSITION ON THE ROLE OF LaMPS IN THE LAKE RESTORATION PROCESS

Binational Executive Committee Consensus Position on the Role of LAMPS in the Lake Restoration Process

The development and implementation of Lakewide Management Plans (LaMPs) are an essential element of the process to restore and maintain the chemical, physical, and biological integrity of the Great Lakes ecosystem. Through the LaMP process, the Parties, with extensive stakeholder involvement, have been defining the problems, finding solutions, and implementing actions on the Great Lakes for almost a decade. The process has taken much longer and has been more resource-intensive than expected.

In the interest of advancing the rehabilitation of the Great Lakes, the Binational Executive Committee calls on the Parties, States, Provinces, Tribes, First Nations, municipal governments, and the involved public to significantly accelerate the LaMP process. By accelerate, we mean an emphasis on taking action and a streamlined LaMP review and approval process. Each LaMP should include appropriate actions for restoration and protection to bring about actual improvement in the Great Lakes ecosystem. Actions should include commitments by the governments, parties and regulatory programs, as well as suggested and voluntary actions that could be taken by non-governmental partners. BEC endorses the April 2000 date for the publication of "LaMP 2000", with updates every two years.

BEC is committed to ensuring a timely review process and will be vigilant in its oversight.

The BEC respects and supports the role of each Lake Management Committee in determining the actions that can be achieved under each LaMP. BEC expects each Management Committee to reach consensus on those implementation and future actions. Where differences cannot be resolved, BEC is committed to facilitating a decision. BEC recognizes the Four-Party Agreement for Lake Ontario and the uniqueness of the agreed upon binational workplan.

The LaMPs should treat problem identification, selection of remedial and regulatory measures, and implementation as a concurrent, integrated process rather than a sequential one. The LaMPs should embody an ecosystem approach, recognizing the interconnectedness of critical pollutants and the ecosystem. BEC endorses application of the concept of adaptive management to the LaMP process. By that, we adapt an iterative process with periodic refining of the LaMPs which build upon the lessons, successes, information, and public input generated pursuant to previous versions. LaMPs will adjust over time to address the most pertinent issues facing the Lake ecosystems. Each LaMP should be based on the current body of knowledge and should clearly state what we can do based on current data and information. The LaMPs should identify gaps that still exist with respect to research and information and actions to close those gaps.

Adopted by BEC on July 22, 1999.

Chapter 2

Public Outreach and Education

This document replaces LaMP 2000 Chapter 2.

Lake Superior's North Shore, Minnesota
Photograph by Dave Hansen, Minnesota Extension Service

Lake Superior Lakewide Management Plan
2004

Chapter 2 Contents

Addendum

Chapter 2
Public Outreach and Education

EXECUTIVE SUMMARY

The Lake Superior Binational Program has a long history of public involvement in the development of the Lake Superior Lakewide Management Plan (LaMP). In particular, the Lake Superior Binational Forum, the primary public group associated with the agencies responsible for carrying out the zero discharge demonstration project, has been key to establishing an effective multi-sector stakeholder process. The Forum has held many workshops over the years for the purpose of acquiring necessary background information to help develop recommendations and proposals for reducing the Lake Superior nine critical pollutants. The Forum has also published many documents on key issues relating to the LaMP.

In addition, a separate Communications/Public Involvement Committee, comprised of staff from government agencies and their partners, was formed to help expand the network of stakeholders and outreach activities. This Committee has produced documents for the purpose of informing the public about all aspects of the LaMP and the Binational Program.

2.0 ABOUT THIS CHAPTER

All the partners involved in the Lake Superior LaMP (i.e., states, provinces and federal agencies, the Tribes/First Nations, industry, the public and others) have long been committed to an open, fair and significant public involvement process. One of the main goals of the Lake Superior Binational Program is, in fact, to promote meaningful public participation and education so as to ensure that the needs and concerns of the diverse population in the Lake Superior basin are met. This section of the LaMP will briefly describe the efforts that have been made to date on public outreach and involvement.

2.1 PUBLIC INVOLVEMENT

A major tenet of ecosystem management is the necessity of continuous involvement of the public that is inclusive and respectful of all viewpoints and stakeholders. Public input and support help ensure that the actions recommended in the LaMP are carried out, leading the way to restoring and protecting the Lake ecosystem. The key to public support and the program's success is effective communication between the government agencies and the diverse population of the Lake Superior basin.

LaMP 2004 is presented as a working document, based on existing information. It was the goal of the Binational Executive Committee to provide a *current* foundation for discussion of Lake Superior efforts, not necessarily a *complete one*. The LaMP will be modified based on new findings and public input. To that end, public input received on

LaMP 2000 has been addressed in LaMP 2004 (e.g. chapter 9 sustainability). This is a necessary step if we are to institute adaptive management on an ecosystem scale.

2.2 PUBLIC OUTREACH/EDUCATION EFFORTS TO DATE

When the Lake Superior Binational Program first began, public involvement activities were carried out primarily by the Binational Forum (see section below). As the Program matured, it became apparent that the government agencies and their partners needed their own separate public outreach mechanism. A separate group, therefore, was formed entitled the Communications/Public Involvement Committee. Over the years, the two groups have worked together, complementing each other's efforts to involve the Lake Superior population.

2.2.1 Lake Superior Binational Forum

Since 1991, the Lake Superior Binational Forum has served as the principal public body providing input to the governments responsible for carrying out the Binational Program. In 1990, the IJC recommended that Lake Superior be a demonstration area where no point source discharge of any persistent toxic substance would be permitted. The purpose of the Forum is to further consultation and participation among government, industry and environmental stakeholders on the restoration and protection of Lake Superior. The Forum is composed of Canadian and American stakeholders representing environmental, Tribal/First Nation, industrial, business, health and academic interests.

The Forum has held various technical workshops since 1991 for the purpose of acquiring necessary background information to help develop proposals for phase-out schedules and reduction recommendations. These recommendations on the nine critical pollutants, for example, may be found in the Stage 2 Lakewide Management Plan. These workshops have been held on mercury, sustainability indicators, PCBs and pesticides, to name a few. A more complete list and description of recent Forum activities may be found in Addendum 2-A.

In addition to sponsoring workshops, the Lake Superior Forum has published a number of reports and documents, ranging from assessing public attitudes toward pollution prevention, to providing feedback and comment on Lake Superior ecosystem objectives and principles.

The Forum has focused on a series of projects that are conducted jointly with the Superior Workgroup. These have included a newspaper insert, the Community Awareness Review and Development (CARD) project, stewardship and awards programs, and workshops on mercury and household garbage burning. Forum activities are reviewed annually during the preparation of the yearly workplan.

2.2.2 Activities of the Communications/Public Involvement Committee

The Communications/Public Involvement Committee of the Work Group is led by staff from Environment Canada and U.S. EPA. The committee implements provisions of a strategy reflecting the Lake Superior Binational Program's long-term commitment to communications, public involvement, outreach, and education.

The Binational Program has produced various documents and brochures for the purpose of informing and educating the public. These documents include a general informational brochure on the Binational Program, as well as a brief introduction of each committee on the Lake Superior Workgroup. Each individual committee has also produced fact sheets that outline the goals and objective of the committee, with past and anticipated activities.

In the fall of 2001, the agencies released another brochure, commemorating the tenth anniversary of the Binational Program. This brochure addressed the accomplishments achieved over the ten year period and addressed the challenges that remain.

The Binational Program has developed a traveling display as a means of outreach and education to the general public. This display has been, and will continue to be, used as a means to publicize Lake Superior and the Binational Program at public meetings, seminars and conferences. The display includes a large photographic display of the lake, with space for fact sheets, brochures, and other documents. The display booth is staffed by members of the Binational Program. In addition, a table-top display developed by University of Wisconsin - Extension is in use around the basin.

The Committee has been revising the main Lake Superior Binational Program web sites (www.epa.gov/glnpo/lakesuperior/ and www.on.ec.gc.ca/water/greatlakes/lakes/superior/intro-e.html) which consist of a home page and supporting pages. This complements the Forum website which can be found at www.superiorforum.info/sitemap.html. In the future, it is anticipated that the main program website will be moved to a joint Canada-U.S. site (www.binational.net) which is a site devoted to binational programs jointly lead by Environment Canada and U.S. EPA.

The Communications/ Public Involvement Committee is also participating in joint outreach and education projects with the Forum such as a newspaper insert and a Lake Superior Awards program (see Addendum 2-A).

A mailing list has been compiled to keep the public informed of new developments in the Lake Superior basin and to provide them with the opportunity to comment. The mailing list includes both U.S. and Canadian government agencies; tribal organizations and First Nations; environmental groups and other public groups.

Assembling material to inform the public on progress toward restoring and protecting Lake Superior is another role the committee fulfills. In that function, the committee is working on success stories for distribution in various newsletters. The Binational Program works in partnership with other organizations toward a common goal of a healthy and safe Lake Superior. A number of examples of outreach activities associated with chemical issues can be found in the LaMP 2004 chapter 4 progress report under Appendix C.

As this Lakewide Management Plan Report 2004 is not intended to be extensively circulated to the public, the agencies plan to produce a separate document to inform the public on Binational Program activities.

2.3 CONCLUSION

The partners involved in the Lake Superior Binational Program have many ongoing outreach, education and communication activities. The partners believe that these will meet the objectives of informing and educating the public about the program, involving the public in the decision making process and educating and motivating stakeholders into action. These agencies are mindful that involvement by people representing a wide range of interests is essential to the success of the Lake Superior Binational Program. Public input and support will help ensure that actions recommended in the program are carried out, leading the way to restoring and protecting Lake Superior.

ADDENDUM 2-A
LAKE SUPERIOR FORUM WORKSHOPS AND ACCOMPLISHMENTS

Forum Accomplishments 2002 and 2003

- Conducted a one-day workshop in September 2003 called "Living on the Edge: Protecting and Restoring Lake Superior's Rivers and Shorelines" that addressed the impacts of human activities on the land and water of riparian areas. About 100 people from Wisconsin, Michigan, Minnesota, and Ontario attended the workshop, held at the Bad River Band of Lake Superior Chippewa reservation in Odanah, Wisconsin. The event was part of a three-day Water and Land Symposium organized by four regional and state partners.

- Conducted a one-day workshop in June 2003, in conjunction with the Work Group, on "Mercury in Our Lives: A Workshop on Mercury Reduction for the Lake Superior Community." The goal of the workshop was to raise public awareness about mercury's effects on human health and the environment. About 65 people attended the workshop held in Thunder Bay, Ontario.

- Provided mini-grants to four community groups for projects and programs to restore or protect natural resources in the basin. These projects included: installing native plants as garden landscaping for the Marquette, Michigan public library; paying for travel expenses for five high school student presentations that were delivered at the sixth biennial Lake Superior Youth Symposium in Ashland, Wisconsin; training volunteer citizens through the Bad River Watershed Association to conduct water quality monitoring activities; and constructing a Forum website.

- Scheduled a Lake Superior Binational Program display at community events around the basin to educate residents about the zero discharge program and the LaMP.

- Organized elected officials in two states, four cities, and one tribe to sign a proclamation declaring the third Sunday in July 2003 as Lake Superior Day. The goal of this day is to celebrate the importance, beauty, and uniqueness of the lake. The following governments signed proclamations that acknowledged a dedication to protecting the lake: the states of Michigan and Wisconsin; the cities of Superior, Duluth, Bayfield, Ashland; and the Red Cliff Band of Lake Superior Chippewa tribal government.

- Collaborated with EcoSuperior and the Work Group in Thunder Bay in April 2002, to hold a workshop, "Burning Household Garbage: Impacts and Alternatives," about the dangers of using burn barrels as a method of disposing of household garbage. The workshop targeted a diverse group of participants and asked for feedback on the extent of burning, the challenges of introducing behavior changes, waste reduction alternatives, and regulations and enforcement.

- In 2003, the Forum initiated two joint projects with the Superior Work Group: 1) a basin-wide Environmental Stewardship Award Program and 2) a newspaper insert.

- The Forum continues to provide input and analysis to governments about LaMP implementation. In addition to holding workshops and public input sessions, the Forum has also written numerous letters to various government representatives about different environmental issues having the potential to negatively impact the Lake Superior ecosystem. Some of these issues include: trap rock mining in Michipicoten Harbour in Wawa, Synfuel Technologies' proposed power plant on the Mission River in Thunder Bay, trading of emission credits among power plants in Wisconsin, and an all weather road proposed for Black Bay Peninsula. The Forum has recommended that the Binational Executive Committee take more of an advocacy role in mercury reduction targets for Lake Superior.

- The Forum has also requested that the Work Group address water diversions, exports, flows and levels in the 2004 LaMP with recommendations for preventing/reducing such threats.

Chapter 3

Ecosystem Objectives

Great Blue Heron, Unknown Area
Photograph by: Don Breneman

Lake Superior Lakewide Management Plan
2000

Chapter 3 Contents

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Chapter 3
Ecosystem Principles and Objectives
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EXECUTIVE SUMMARY

The Binational Program is committed to the objective of zero discharge and to a broader program to restore beneficial uses and to protect and restore ecosystem integrity in Lake Superior and its watershed. A Vision for Lake Superior (see Chapter 1) expresses this commitment to the Lake Superior ecosystem and its landscapes. It reflects the diverse pathways and mechanisms by which humans and nature interact within land and water ecosystems, and challenges the inhabitants of the Lake Superior watershed to accept personal responsibility for protecting the Lake and the landscape that sustains it. The Binational Program expanded the vision into more specific and technically precise language. The result is *Ecosystem Principles and Objectives, Indicators and Targets for Lake Superior*, first published in 1995 is now being used to guide ecosystem management and monitoring in the Lake Superior basin. and revised a number of time since then. (Access the document at: www.cciw.ca/glimr/lakes/superior/intro.html under the Publications section.) This chapter provides an overview to *Ecosystem Principles* and its approach to ecosystem management for Lake Superior.

3.0 ABOUT THIS CHAPTER

The Binational Program is committed to the objective of zero discharge and to a broader program to restore beneficial uses and to protect and restore ecosystem integrity in Lake Superior and its watershed. A Vision for Lake Superior (see Chapter 1) expresses this commitment to the Lake Superior ecosystem and its landscapes. It reflects the diverse pathways and mechanisms by which humans and nature interact within land and water ecosystems, and challenges the inhabitants of the Lake Superior watershed to accept personal responsibility for protecting the Lake and the landscape that sustains it. The Binational Program expanded the vision into more specific and technically precise language. The result is *Ecosystem Principles and Objectives, Indicators and Targets for Lake Superior*, first published in 1995 is now being used to guide ecosystem management and monitoring in the Lake Superior basin. and revised a number of time since then. (Access the document at: www.cciw.ca/glimr/lakes/superior/intro.html under the Publications section.) This chapter provides an overview to *Ecosystem Principles* and its approach to ecosystem management for Lake Superior.

3.1 PURPOSE

Ecosystem Principles and Objectives for Lake Superior, a discussion draft is intended to:

1) expand the broad objectives of A Vision for Lake Superior into more specific ecosystem principles and objectives for key elements of the Lake Superior ecosystem, including aquatic communities, terrestrial wildlife, habitat, human health, and sustainability. This discussion document has undergone review among Great Lakes practitioners. Ecosystem objectives developed by consensus do not obviate or override regulations, laws and guidelines set by governments and resource regulatory agencies. Rather, the *Ecosystem Principles and Objectives*, *Indicators and Targets for Lake Superior* have been prepared to encourage informed discussion of the vision and practice essential for proactive, sustainable and coordinated management of the Lake Superior ecosystem.

2) facilitate progress towards a set of informative ecosystem indicators, with quantitative targets, by which the health of the Lake Superior basin ecosystem, including its physical, biotic and cultural elements, can be measured.

3) provide guidance for land and water management in the Lake Superior ecosystem.

3.2 SCOPE AND BACKGROUND

Lake Superior ecosystem objectives and sub-objectives were developed by each of the Lake Superior Work Groups committees: chemical, aquatic community, terrestrial wildlife community, habitat, human health and developing sustainability. Table 3.1, Summary of Objectives and Sub-Objectives, presents each committees objective and details that elaborate and clarify them in the sub-objectives column.

3.2.1 Indicators and Targets for Lake Superior

Using the same set of themes the Superior Work Group and partners were invited to draft a set of ecosystem indicators and targets for Lake Superior as measurements of progress towards Ecosystem Principles and Objectives. The Ecosystem Indicators and Targets discussion paper features specific indicators and targets.

A typical indicator identifies a practical measurement such as the abundance or distribution of a plant or animal species or an economic measure that tells us something significant about the health of the Lake Superior ecosystem. Each indicator is accompanied by a target that specifies the desired level of the indicator and its justification.

The objective of the Ecosystem Indicators and Targets discussion draft, was to attempt to specify a comprehensive spectrum of ecosystem indicators and targets. It has and will provide a reference point for discussion and refinement of binational ecosystem management and monitoring in the Lake Superior basin. The ecosystem objectives and indicators have been refined and updated since the document's original release. A Lake Superior Binational Monitoring Workshop held on October 25-27, 1999, to refine these ideas and will undergo further development towards a broad community consensus. The results will be published in the summer of 2000.

Table 3-1 Summary of Objectives and Sub-Objectives

3. Terrestrial Wildlife	The Lake Superior ecosystem should support a diverse, healthy and sustainable wildlife community in the Lake Superior Basin.	• There is a wildlife community-based program to monitor the health of LSB ecosystems. • Species at risk/concern (federally threatened and endangered) are recovered. • Encourage disturbances that are within natural variation. • Manage land and wildlife populations using practices that mimic natural disturbances. • Understand the relationship between wildlife and disturbance. • Keep wildlife species free of contamination. • Encourage the use of native species in all remedial projects. • h)Prevent and control the spread of undesirable exotic species. • Educate the public to integrate the values of wildlife in economic development. • Meet the restoration needs of wildlife communities.
4. Habitat	To protect and maintain existing high-quality habitat sites in the Lake Superior basin and the ecosystem processes that sustain them. Extensive natural environments such as forests, wetlands, lakes and watercourses are necessary to sustain healthy native animal and plant populations in the Lake Superior ecosystem, and have inherent spiritual, aesthetic and educational value. Land and water uses should be designed and located in harmony with the protective and productive ecosystem functions provided by these natural landscape features. Degraded features should be rehabilitated or restored where this is beneficial to the Lake Superior ecosystem.	• Ecological health of the Lake determined largely by the health of tributary lakes and rivers; land use planning/regulation should eliminate/avoid destructive water linkages and foster healthy land-water linkages; • Long-term consequences of incremental landscape change, habitat destruction and fragmentation should be avoided through research and planning; • Importance of nearshore, shoreline and wetland habitats should be addressed through identification, protection and restoration of sites for reproduction and rearing of fish, water birds, mammals, other wildlife and plants;
5. Human Health	The health of humans in the Lake Superior ecosystem should not be at risk from contaminants of human origin. The appearance, taste and odour of water and food supplied by the Lake Superior ecosystem should not be degraded by human activity.	• Fish and wildlife should be safe to eat, and consumption should not be limited by contaminants of human origin; • Water quality should be protected where currently high, and improved • where degraded; communities, industries and regulators outside the basin should be informed of consequences of long-range atmospheric transport of contaminants into the basin; • Lake Superior should be safe for total body contact activities, including areas adjacent to urban and industrial areas; • Air quality should be protected where currently high, and improved where degraded; communities, industries and regulators outside basin should be informed of consequences of long-range atmospheric transport of contaminants into the basin;

Table 3-1 Summary of Objectives and Sub-Objectives

6. Developing Sustainability	Human use of the Lake Superior ecosystem by all people in the watershed should be consistent with the highest social and scientific standards for sustainable use. Land, water and air use in the Lake Superior ecosystem should not degrade it, nor any adjacent ecosystems. Use of the Basin's natural resources should not impair the natural capability of the Basin ecosystem to sustain its natural identity and ecological functions, nor should such use place at significant risk the socioeconomic and cultural foundations for any group of citizens in the watershed, nor should we deny current and future generations the benefits of a healthy, natural Lake Superior ecosystem. Policies directed at the wise management of natural and social resources in the Basin should not usurp the right of local communities to determine their future within the guidelines established by existing statutes and regulations. Technologies and development plans that preserve natural ecosystems and their biodiversity should be encouraged.	• Public and private decisions should be based on understandings, rooted in formal and informal educational settings, which contribute to the integrity and stability of social and biotic communities. • The Lake Superior ecosystem provides resources and services to humans. These include air, water, fiber, minerals, energy, waste transport and treatment, food, recreation, and spiritual sustenance. These resources should be valued as environmental capital, in the same way that other capital is assigned value. • Institutional capacity to integrate technology and sustainable design should be developed within the Lake Superior ecosystem that are compatible with existing and emergent social conditions. • The basis for guiding sustainable development at the scale of the Lake Superior ecosystem (especially in reference to community land use or comprehensive planning) should be the pattern of land, water, and air use, as these affect ecological, social and economic processes.

Chapter 4

Lake Superior
Critical Pollutants Progress Report

Insert at beginning of LaMP 2000 Chapter 4. This chapter will be updated in 2005 for inclusion in the LaMP 2006 report.

Burn Barrel
Photo by EcoSuperior.com

Lake Superior Lakewide Management Plan
2004

Chapter 4 Contents

CHEMICAL COMMITTEE WORKPLAN OVERVIEW 2004 TO 2006

The Chemical committee LaMP 2004-2006 workplan will be available in May 2004. Below are themes that the committee anticipates to be areas of activity for the next two years. The workplan will contain details regarding specific activities and jurisdictions.

- Programmatic: Agencies will continue to implement the activities identified in LaMP 2000. In 2005, the agencies will prepare a report that will evaluate the effectiveness of these activities in meeting the 2005 milestones and update the chemical reduction strategies to address future milestones.

- Funding: Lake Superior Binational Program agencies will pursue funding to continue successful pollution prevention projects and initiate pilot projects in the basin. Great Lakes funding programs are crucial funding sources for projects that carry out the zero discharge demonstration for Lake Superior.

- Advocacy: Implementation of LaMP projects has been beneficial to stakeholders within the Lake Superior basin and beyond. The challenge for agencies is to advocate this benefit to decision makers and the public to ensure continued support for toxic chemical reduction activities.

- Outreach: Agencies will continue communication and outreach activities that will achieve measurable progress toward the Binational Program goal of zero discharge for nine critical pollutants.

- Contaminated Sediments: Efforts leading to sediment remediation will continue in both countries. U.S. programs include the federal Superfund program and state contaminated sediment clean up programs. The U.S. federal Great Lakes Legacy Act funding will be available for the first time in 2004 for contaminated sediment remediation in Areas of Concern. In Canada, the process of conducting sediment assessments, selecting remediation options, and making funding decisions is underway for three Lake Superior AOCs.

- Stormwater Management: This will continue to be an important focus for several communities and government agencies. Stormwater controls will help prevent loadings of polynuclear aromatic hydrocarbons (PAHs) and heavy metals to the waters of the Lake Superior basin. Public education will be a critical element of the stormwater projects in the basin.

Chapter 4
Lake Superior Critical Pollutants Progress Report

This report provides an update of activities related to critical pollutants in the Lake Superior basin. It is organized to provide background on the program and to report agency activities related to critical pollutants between 2002 and 2004.

4.0 THE ZERO DISCHARGE DEMONSTRATION PROGRAM

Reducing toxics loadings to Lake Superior is a key component of the effort to achieve sustainability in the basin. The LaMP Stage 2 sets a goal of eliminating sources of the nine critical pollutants in the Lake Superior basin by 2020, with interim targets in 2000, 2005, 2010 and 2015 (Table 1). The baseline for the reduction targets is 1990. The Lake Superior Binational Program's Zero Discharge Demonstration Program (ZDDP) is a unique experimental program intended to end the use of these nine critical pollutants in industrial processes or products and to prevent their release in the Lake Superior Basin.

Lake Superior Canadian north shore at Marathon, Ontario
Photo by John Marsden, Environment Canada

Table 1. Lake Superior Load Reduction Schedule
(percentage reductions)

Chemical	2000	2005	2010	2015	2020
Mercury	60	--	80	--	100
PCBs	33	60	95	--	100
Dioxin, HCB, OCS	--	80	--	90	100
Pesticides: Aldrin/Dieldrin Chlordane DDT/DDE Toxaphene	100	--	--	--	--

Why Zero Discharge for Lake Superior?

Lake Superior provides the best opportunity among the Great Lakes to achieve zero discharge. The governments around Lake Superior announced the Binational Program to Restore and Protect the Lake Superior basin in 1991, with an agreement to work together on the zero discharge demonstration and on broader ecosystem issues. The 1991 agreement stresses voluntary pollution prevention, but acknowledges that enhanced mandatory controls may be necessary.

Other Lake Superior Critical Pollutants

Although the load reduction schedules apply only to the pollutants targeted in the zero discharge demonstration, the LaMP Stages 1 and 2 identify other critical pollutants of lakewide concern for Lake Superior ("lakewide remediation" pollutants). The LaMP goal for lakewide remediation pollutants is to reduce inputs or remediate contaminants so that beneficial uses are restored. These pollutants include polynuclear aromatic hydrocarbons (PAHs), Alpha-BHC, Cadmium, Heptachlor/heptachlor epoxide, and dioxin and furan congeners expressed as toxic equivalents (with the exception of 2,3,7,8-TCDD, which is a zero discharge pollutant). Section 4.2.5 of this chapter discusses recent actions to reduce lakewide remediation pollutants from contaminated sediment and stormwater runoff.

Reducing Pollutant Concentrations in the Environment

Enforcement of strong environmental regulations, changes in industrial development patterns, implementation of pollution prevention, and the efforts of individual citizens have significantly reduced releases to the lake. However, the goal of zero discharge is a challenging one, and a significant amount of work remains to be done.

The ZDDP and other programs reduce toxic chemicals at their sources and result in their eventual reduction in the ecosystem. Concentrations of a suite of toxic organic contaminants in water including the Lake Superior critical and lakewide remediation pollutants declined more than 50 percent between 1986-87 and 1996-97. Nevertheless, of the nine critical pollutants, dieldrin, mercury, PCBs and toxaphene concentrations in Lake Superior continue to exceed the most stringent water quality standards.[1,2]

Herring Gull eggs have been collected and analyzed annually from the same two Lake Superior sites since 1974 for selected contaminants. The annual data from 1974 to 2002 were analyzed by change point regression.[3] In summary, 64.3% of contaminant-colony comparisons are declining as fast as or faster now than they were earlier in the study, while 28.6% have declined more slowly in recent years (see Appendix A).

In terms of spatial patterns among the 15 Herring Gull annual monitoring sites from throughout the Great Lakes, data for 1998 to 2002 show that for dieldrin and heptachlor epoxide, gull eggs from both Granite Island and Agawa Rocks on Lake Superior were among the most contaminated sites. The site ranked 3rd and 4th most contaminated, respectively (see Appendix A). DDE, HCB, PCB, TCDD and Hg values from the two sites did not differ from sites whose values were in the lower half of the overall range.

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[1] Open Lake Monitoring Program, Environment Canada, 2000.

[2] Rolfhus, K.R., H.E. Sakamoto, L.B. Cleckner, R.W. Stoor, C.L. Babiarz, R.C. Back, H. Manolopoulos and J.P. Hurley. 2003. The distribution of mercury in Lake Superior. Environmental Science and Technology. 37(5): 865-872.

[3] Pekarik and Weseloh. 1998

The Ontario Sport Fish Contaminant Monitoring Program reports toxaphene, PCBs and mercury cause 97% of consumption restrictions in Ontario Lake Superior sport fish. Since 1976 PCB concentrations in 55 cm lake trout have decreased by 82% and now average 195 ppb (compares with the 500ppb consumption guideline). Over the same period, mercury concentrations have dropped by 64% to an average of 0.19 ppm (compares with 0.45 ppm consumption guideline). Since 1981, toxaphene levels have declined by 59% to an average of 227 ppb (compares with 201 ppb consumption guideline). As a result, toxaphene remains the major cause of Ontario consumption restrictions on Lake Superior sport fish. Between 1997 and 2003, the proportion of Lake Superior sport fish with consumption restrictions has fallen from 41.9% to 25.8%, almost entirely because of declining toxaphene levels.

The number and geographic extent of sport fish consumption advisories in Lake Superior is expected to decrease as contaminant concentrations decline. However, the ecosystem requires decades to purify itself, and agencies will likely continue to issue sport fish advisories for some time.

Progress on pollutant reductions requires actions on many levels–local, state, provincial, federal, and tribal governments, industrial facilities, trade associations and individuals must all support the effort. Actions taken by all these groups have successfully reduced the critical pollutants in the Lake Superior basin, but more needs to be done.

Activities to Meet the Zero Discharge Goal

The efforts to reduce releases of the nine critical pollutants are increasing as governments and citizens work to identify creative ways to reduce the use and discharge of these chemicals. Much progress has been made through changes in industrial activity and through efforts by municipalities of all sizes and community-based programs. While these have been successful, there is also a need to address pollution sources from outside the basin.

Great Lakes Binational Toxics Strategy – The Great Lakes Binational Virtual Elimination Strategy (BTS) has had many successes in seeking Virtual Elimination of targeted toxic substances. For the latest update, please see their web site at www.epa.gov/glnpo.

Recent Municipal Activities

There are numerous activities undertaken each year by municipalities in the basin to reduce pollutants. Below are two noteworthy examples.

Sault Ste. Marie Household Hazardous Waste Collection Facility

The City of Sault Ste. Marie and Chippewa County in Michigan carried out special household hazardous waste collections (HHW) in 1998 and 1999. After collecting over 13,600 kilograms (30,000 pounds) of HHW, it was evident that there was a need for these services. The partners, including the city, county, Northern Transitions Inc., Lake Superior State University and Waste Management Inc., are working to establish a permanent collection site.

City of Thunder Bay

The City of Thunder Bay is undertaking a comprehensive $97 million (Canadian) Pollution Prevention Control Plan (2003-2007). With $25 million in support from the federal government, the infrastructure program includes construction of the new secondary sewage treatment plant ($55M), further enhancement of sewage treatment processes to eliminate ammonia from the treated effluent ($9M) and to change disinfection to UV radiation ($6M). Other improvements include continuation of the storm water separation program ($5M), and rehabilitation of sanitary sewers to reduce infiltration of ground water into the Sanitary Sewer System ($11M). The extended Plan has been endorsed by all levels of government and by numerous community groups.

National and International Activities

National and international programs have an important role in protecting Lake Superior from inputs of critical pollutants, by reducing releases both within the basin and, in the case of pollutants that are atmospherically-transported long distances, beyond the basin. With its large surface area, Lake Superior receives a relatively high deposition of airborne toxics from distant and local sources.

In 2001, the United States and Canada became signatories to the Stockholm Convention on Persistent Organic Pollutants (POPs), which restricts the global production and use of twelve chemicals, including the Lake Superior critical pollutants PCBs, dioxin, hexachlorobenzene (HCB), and the pesticides chlordane, DDT, dieldrin, and toxaphene. Canada has ratified this treaty and, in the United States, the Senate Public Works and Environment Committee has recommended ratification. The Convention comes into force in 2004. In addition, both nations are participating in the Mercury Programme of the United Nations Environment Program, which has urged all countries to adopt goals and take actions, as appropriate, to identify populations at risk and to reduce human-generated releases.

At the national level, both countries have implemented actions to reduce air emissions of mercury, dioxin, HCB, and B(a)P. In addition, both countries are pursuing reductions of use and/or release of these substances and PCBs under the Great Lakes Binational Toxics Strategy, through voluntary agreements and information sharing about cost-effective reduction opportunities for state and local governments, industry, and non-government organizations. The Binational Household Garbage Burning Strategy was piloted in the Lake Superior basin. It will now serve as a model for other regions of both countries.

Air Emissions Regulations and Standards

Most significantly, regulation of municipal waste, hospital waste, hazardous waste, and sludge incinerators is yielding significant reductions in air emissions of mercury and dioxins. In Canada, the Ontario government amended the *Existing Hospitals Regulation* (Ontario Regulation 323/02) requiring all existing hospital incinerators to be closed by December 2003. Hospital incinerators were estimated to be the 13th largest emitters of mercury and the largest emitters of dioxins in Ontario. Once these closures are complete, open burning of household waste will be the largest dioxin source category in the province. A proposed Canada-wide Standard for conical waste combustors has implications for Lake Superior. The standard would prevent the use of new conical waste combustors in Canada.

In the United States, control standards for small municipal waste combusters were finalized, and compliance is already required at large municipal waste combusters, hospital incinerators, and hazardous waste combusters. The amount of dioxin emissions reductions achieved at large municipal waste combustion units between 1990 and 2000 is 99%+. Also in the United States, mercury reduction requirements have been finalized in the last two years for mercury cell chlor-alkali plants and iron foundries, and proposed for industrial boilers.

The U.S. EPA has proposed regulations to reduce mercury emissions from coal-fired electric utility boilers, the largest source of mercury emissions in the United States. The proposal includes two primary regulatory alternatives. The first is a control technology standard that would achieve 29 percent reduction in mercury emissions by 2009. Under this option, U.S. EPA would impose emission rate limits on individual boilers in pounds per megawatt hour of electricity generated. The other option is a two phase "cap-and-trade" program, ultimately resulting in emissions reductions of 69 percent. This program would be implemented through state plans, under which states would receive mercury emissions "budgets" that they could meet either by setting emissions limits on individual boilers or by distributing mercury emissions allowances. These allowances could be traded with other sources across the country or banked for future use. The first phase of reductions would begin in 2010, with the final phase in 2018.

A Canada-wide Standard is also being developed for coal-fired power plants. The Canadian Council of Ministers of the Environment (CCME) committed in 2003 to set a Canada-wide Standard in 2005 to reduce mercury emissions form the coal-fired electric power generation sector by 2010. A 60 to 90% capture rate of mercury from coal burned is being considered nationally.

In addition, the CCME has agreed to initial actions by 2005 to reduce emissions from residential wood-burning appliances by updating standards for new wood-burning appliances, and exploring options for a national regulation and a change-out program. These measures would reduce HCB and B(a)P emissions. A U.S. regulation limiting emissions from hydrochloric acid production, finalized in 2003, is expected to reduce emissions of HCB.

Other Significant Regulations

In Ontario, *Regulation 196/03* came into effect in November 2003 requiring that all dental offices, in which dental amalgam is placed, repaired or removed, have a properly installed dental amalgam separator. The Royal College of Dental Surgeons of Ontario administers the regulation. In support of the regulation, the College has prepared a “Standard of Practice for the Profession” guide for the disposal of dental amalgam and mercury wastes. The separators are required to meet or exceed the ISO standard for these devices.

Wisconsin drafted regulations to reduce mercury air emissions from utilities and other large sources in the state. The effort began in 2000 with petitions by citizens and environmental organizations. After considerable work with the public and industry, the Wisconsin Department of Natural Resources Board adopted mercury emission regulations in 2003. However the regulatory package did not receive endorsement by the Wisconsin legislature and hence was not enacted. Although the rule-making was controversial, the rationale recognized the severity of the mercury problem state-wide and recognized a state regulatory role in addition to potential federal actions.

4.1 LaMP STRATEGIES

The LaMP 2000 report and the work of the committee are built around 23 pollutant reduction strategies. These will be reviewed and updated for the LaMP Chemical Milestone Report to be drafted in 2005. Fulfillment of the actions associated with the strategies will bring us closer to 2005 and 2010 milestones.

Table 2. Chemical Strategies

	MERCURY
Mercury Strategy 1:	Encourage voluntary reductions of the use, discharge and emission of mercury.
Mercury Strategy 2:	Develop incentives to reduce mercury use.
Mercury Strategy 3:	The mining and electric utility sectors must reduce mercury by half in order to meet the 2010 milestone.
Mercury Strategy 4:	Mercury-bearing products must be reduced in order to halve the amount of mercury in products by 2010.
Mercury Strategy 5:	Proper identification, collection and disposal of mercury-bearing products in the basin.
Mercury Strategy 6:	Regulations, compliance, and enforcement.
Mercury Strategy 7:	Remediation of mercury contaminated sediments.
	PCBs
PCBs Strategy 1:	Encourage voluntary reductions of the use and storage of PCBs.
PCBs Strategy 2:	Untested equipment must be tested and the inventory must be kept current.
PCBs Strategy 3:	Decommissioning, removal and destruction of PCBs.
PCBs Strategy 4:	Government agencies to undertake PCB training programs.
	PESTICIDES
Pesticides Strategy 1:	Collection of remaining stockpiles of banned pesticides.
Pesticides Strategy 2:	Engage other programs that deal with banned pesticides.
Pesticides Strategy 3:	Educate residents about the use of pesticides.

DIOXIN, HCB, OCS

Dioxin Strategy 1:	Encourage voluntary reductions of the discharge and emission of dioxin/HCB/OCS.
Dioxin Strategy 2:	Develop incentives to reduce dioxin/HCB/OCS.
Dioxin Strategy 3:	Pollution prevention is the preferred approach to inhibit the formation of dioxin/HCB/OCS in incineration.
Dioxin Strategy 4:	There is a continuing role for the pulp and paper industry to play in dioxin reductions.
Dioxin Strategy 5:	Identify sources of dioxin/HCB/OCS.

STRATEGIES THAT APPLY TO MULTIPLE POLLUTANTS

General Strategy 1:	Lake Superior goals must be taken into account by other programs.
General Strategy 2:	Sites contaminated by the nine designated chemicals must be identified and cleaned up.
General Strategy 3:	Pollution prevention is the preferred approach to achieving the goal of zero discharge.
General Strategy 4:	Lake Superior communities must be supported in their pursuit of the zero discharge demonstration program and encouraged to share their expertise to help others protect the lake.

4.2 LaMP ACCOMPLISHMENTS 2002 TO 2004

Actions undertaken or completed since the release of the LaMP 2002 report are summarized below. Actions not reported in the 2002 update are also presented here.

4.2.1 Mercury Strategies and Related Activities

Voluntary programs for mercury reduction in the basin range from national programs, to those that apply in a particular jurisdiction, to very specific voluntary reductions. Some examples of voluntary reduction programs include the following:

- The Minnesota Dental Association, in conjunction with Metropolitan Council Environmental Services, kicked off a statewide effort in 2003 to encourage voluntary installation of amalgam separators in all dental offices statewide by 2005. More than 1,100 dentists have signed up already.

- In Ontario, EcoSuperior (a Thunder Bay non-profit organization), and the Clean Air Foundation (with funding from Ontario Ministry of the Environment, Environment Canada and Ontario Power Generation) have set up a program to recover mercury switches from automobiles. To date EcoSuperior has collected 1,340 switches diverting more than 1 kilogram of mercury destined for steel making and release to the atmosphere from blast furnaces. The program currently involves nine auto companies in Thunder Bay, Marathon and Sault Ste. Marie. Fluorescent Lamp Recyclers collects the mercury switches reclaimed from automobiles in this program.

- Initially coordinated by EcoSuperior, regional industries and public sector establishments have set up a voluntary fluorescent lamp recycling and disposal program for large scale operations using Fluorescent Lamp Recyclers, Inc. Recently MGM Electric Limited in Thunder Bay has set up a fluorescent recycling program for the commercial sector. Bulbs are collected at MGM on a "pay as you go" basis.

- In 2002, EcoSuperior set up a month-long fluorescent light collection event for Thunder Bay homeowners and small business. This event has been expanded so that in 2004 the event will run for several months and will include depots in both Thunder Bay and Wawa open to homeowners and small business. Support for fluorescent light recycling is provided by Ontario Power Generation, the Great Lakes Sustainability Fund and the Ontario Ministry of Environment.

- Taken together the fluorescent tube collection programs in the Ontario portion of the basin recover approximately 500 grams of mercury annually (based on 20 mg mercury vapour per lamp).

Collecting fluorescent bulbs to recycle mercury at EcoSuperior, Thunder Bay, Ontario
Photo by Jim Bailey, EcoSuperior

- In Wisconsin, the City of Superior set up a fluorescent bulb recycling program where local hardware stores provide collection facilities and local industries (Murphy Oil USA and Superior Water Light and Power) provide funds for bulb recycling.

- The Murphy Oil refinery and City of Superior received EPA GLNPO funding to develop a plan to eliminate the use of mercury and PCB containing equipment at the refinery. The project includes development of a purchasing policy and project outreach that can be used by other industrial facilities.

- Algoma Steel Inc. in Sault Ste. Marie, having previously sent its in-storage mercury for recycling has agreed to no accumulation of new mercury inventories and has put in place a direct removal policy.

It is possible to reduce mercury in the *utility and mining sectors* through the use of new technology and changes in patterns of energy consumption. Cost-effective pollution control technologies are under exploration for coal-fired power plants and may be applicable for some mining technologies. A new gold mining technology is already in place and taconite processing is being studied for potential mercury reductions.

- In late 2002, the Golden Giant Mine in Manitouwadge, Ontario introduced a new processing technology that uses an Australian designed “Acacia” reactor. This is the first installation in North America for this type of process that allows on-site low temperature treatment of gravity recovered gold rather than off-site high temperature smelting. The process includes removing mercury as mercury sulphide (cinnabar). Besides the economic benefits resulting from the on-site processing of gravity gold, there are environmental benefits. Previous gravity gold shipments resulted in 200 kilograms of contained mercury being shipped off-site each year. The new process reduces these off-site shipments by over 90%. All of the contained mercury in the “Acacia” reactor is removed as an amorphous mercury sulphide (cinnabar) precipitate and is stored with similar sulphide bearing tailings material within the tailings management area.

- The Minnesota Department of Natural Resources Minerals Division finished a report in 2003 for the Minnesota Pollution Control Agency regarding scrubber water from taconite processing. Samples were taken from four taconite processing plants. Although the data were variable, the researchers believe these variations imply relationships between processing technique and mercury recovery.

While new technologies are being developed that limit mercury emissions, *energy conservation and alternative energy sources* are important options for the basin. The LaMP 2002 noted a variety of national energy regulations that are in the development stage. Energy related initiatives in the basin since 2002 include the following:

- The Ontario government has committed increasing the share of "renewables" in the Ontario power mix by 10 percent or 2700MW by 2010 with a five percent target of 1350 MW by 2007.

- Pending the outcome of an environmental assessment under the Canadian Environmental Assessment Act, Superior Wind Energy Inc. is proposing to construct a low-density wind park on forested land in the District of Algoma north of Sault Ste. Marie. The project is in two phases of 100MW each using 55 wind turbine generators. The project is expected to begin in 2005 with a cost estimated of $180 million (Canadian).

- In Duluth, Minnesota, the new Hartley Nature Center will be nearly energy self sufficient. Solar panels cover the roof, passive heat and lighting was incorporated in the design and a geothermal heat pump is the primary heating and cooling system. In addition, the building will use no polyvinyl chloride and wood siding for the structure was purchased from Minnesota forests that have been designated as sustainable by the Forest Stewardship Council.

- The Duluth Zoo was the first Northeastern Minnesota recipient of a Rebuild Minnesota grant. The $300,000 (US) renewable energy demonstration program includes installation of some cutting-edge technology including solar hot water and eventually space heating equipment for the animal barn; photovoltaic cells to charge electric vehicles; and a geothermal heat exchanger that uses the earth's crust to cool polar bear and seal pools. The new equipment is projected to trim about $136,000 (US) from the zoo's annual energy bills.

- Grand Portage Reservation received results from its anemometer study and is continuing to pursue wind as an energy source. Bad River and Bay Mills Reservations are assessing the feasibility of developing wind generation.

- Minnesota Power constructed an innovative, high-efficiency home in a northern climate with a goal of heating it for $300 (US) or less per year in Duluth, Minnesota. The Millennium Star house incorporated energy efficient design, materials and appliances. Information about the project is available on the web at http://www.mnpower.com/energyhome.

The strategy for *mercury bearing products* organizes actions for citizens to reduce the use of mercury containing devices and promotes the use of alternative products and proper disposal of mercury containing devices. As in LaMP 2002, mercury collection projects continue in the basin. Some actions that have taken place since 2002 include the following:

- Auto switch programs have been implemented in several communities in the US and Canada. In Wisconsin, Wisconsin Indianhead Technical College and the City of Superior sponsored an auto switch-the-switch event. Approximately 60 cars were checked by the students from the mechanical program and 38 mercury switches were replaced. The Cities of Superior and Ashland set up a program with auto dealers to replace mercury switches in vehicles before they leave the lots. The auto dealers display posters and flyers advertising their participation.

- Bad River Reservation carried out an abandoned car program to survey abandoned cars; remove their switches, fluids and batteries; and develop an abandoned car ordinance.

- EcoSuperior has established collection depots in Thunder Bay, Nipigon, Schreiber, Terrace Bay, White River and Sault Ste. Marie for thermostats. Collected thermostats are sent to a processor where mercury is removed and sent to Honeywell Inc. for re-use in new products. The project has collected approximately 500 grams of mercury. In the U.S. a program sponsored by Honeywell and WDNR established eight industrial supply businesses in Duluth and Superior as permanent collection depots for mercury containing thermostats from contractors and builders. Participating businesses are recognized with certificates.

- The City of Floodwood, MN also experimented with a thermostat swap. The city, population of 487, collected 113 mercury thermostats (about 300 grams of mercury).

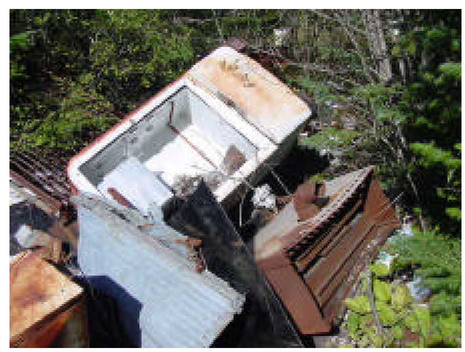
- The Minnesota Pollution Control Agency purchased some mercury free thermostats for a thermostat swap project that is under development.

- In 2003, the Minnesota Pollution Control Agency purchased 30 amalgam separators for use by dentists who do not yet have one. Nineteen have been distributed to date.

- Mercury thermometer collections and swaps were implemented in Thunder Bay, Nipigon, Terrace Bay, Marathon, Wawa and Sault Ste. Marie, Ontario; Buhl, Floodwood, Hibbing and Hoyt Lakes, Minnesota. In many cases outreach materials were available to the public. In the Wisconsin portion of the basin, over 8,000 mercury thermometers have been collected since 2000.

- The City of Buhl, Minnesota used Minnesota Pollution Control Agency funding to purchase sodium vapour security lighting to replace the old mercury vapour lamps.

- Abandoned waste collections were carried out by Lake County and St. Louis County in Minnesota using USEPA funding. About 55 tons of trash was hauled out of the woods and recycled or landfilled. Similar collections were also carried out by recreational groups in Wisconsin and Minnesota. White goods can contain mercury switches and PCB ballasts or capacitors.


Abandoned white goods, Minnesota
Photo by Hank Fisher, Minnesota Office of Environmental Assistance

- White goods are now collected at Thunder Bay landfills. To make use of this service, citizens must have the freon gas removed and the appliance tagged. Abandoned appliances are collected separately and drained by a contractor. The mercury-containing switches are removed by a contractor (Lakehead Scrap Metals) before the metal appliances are shredded.

- Periodic curbside white goods collections have been carried out at Grand Portage and Fond du Lac Reservations.

- The City of Thunder Bay has partnered with EcoSuperior to divert mercury bearing products from reaching landfills. Collected products include button batteries, fluorescent lights and thermostats.

There has been significant *activity to inform the public* on the hazards of exposure to elemental mercury and how to recognize and properly dispose of mercury bearing products. In many cases, alternative products are now available to the public. The Lake Superior Binational Forum has been involved in a number of mercury reduction activities. (For a description of the Forum's Chemical Committee's activities, see Appendix A.) Recent projects in the basin include the following:

- Minnesota's *Mercury Free Zone* has spread statewide. As of September 2003, 284 kilograms (625 pounds) of mercury has been removed from schools; 238 out of the 1,800 schools have signed the mercury free pledge; Minnesota Pollution Control Agency staff and Clancy (the mercury detecting dog) have assessed 96 schools for mercury contamination; and they have educated at least 9,418 students, teachers and school faculty.

Household hazardous waste collection event in Manitouwadge, Ontario
Photo by Jim Bailey, EcoSuperior

- The Northwest Wisconsin Mercury Free Schools program has reached 85 schools. City of Superior staff presents programs to all age school groups. Schools pledge to remove mercury products and elemental mercury. The program includes technical assistance and facility audits. Northwest Wisconsin Regional Planning Commission collects the mercury devices and other hazardous waste. Thousands of mercury items and hundreds of pounds of mercury have been collected through this program.

- The St. Louis Riverwatch Mercury Curriculum was completed and distributed in September 2003. It was written by eleven educators and related professionals from Minnesota.

- The Lake Superior Binational Program sponsored a workshop in Thunder Bay in June 2003. Entitled *Mercury in Our Lives: A Workshop on Mercury reduction for the Lake Superior Community*, the workshop featured speakers on human health issues, the mercury inventory of Lake Superior sources and a variety of mercury reduction activities, including both the municipal sector and the industrial and commercial sectors.

- Environment Canada and Ontario Ministry of the Environment have worked with a group of stakeholders including Dental and Dental Hygienists Associations, universities and colleges, the City of Toronto and the Royal College of Dental Surgeons to develop a Best Management Practices manual. Now available for the dental community, the manual covers procedures for collection and disposal of dental wastes including mercury.

- Similarly, the City of Superior offered Dental Office Best Management Practices workshops to all Douglas County dentists. City of Superior and City of Ashland pollution prevention project staff have now visited most of the dental offices in the basin in Wisconsin to present training in best management practices.

- Wisconsin Department of Natural Resources produced a 16-page Lake Superior article for the Wisconsin Natural Resources magazine.

- The Lake Superior Binational Program prepared a poster for the 2003 International Joint Commission mercury workshop which included a timeline of progress since 1990 and some of the significant events that drove concerns about the effect of mercury on human health.

- The Minnesota Pollution Control Agency printed mercury and PCB "use tree" posters for basinwide use. These posters illustrate the various ways in which mercury and PCBs have been used and update the use trees depicted in the Stage 2 LaMP.

- Wisconsin agencies and individuals developed and produced poster displays on Lake Superior issues including mercury and burn barrels. The posters were used at county fair displays during the summer of 2002 and are placed in several locations including the Northern Great Lakes Visitor Center.

- The Red Cliff Band of Lake Superior Chippewa has hired a mercury elimination coordinator to work with the community on mercury reduction and burn barrel projects. A June 2003 community workshop kicked off the project, which includes a radio show that combines music and environmental messages on the Red Cliff radio station.

Although mercury reduction activities are important, *monitoring* to assess progress on the Zero Discharge Demonstration and track the levels of mercury in the environment is vital. Current mercury monitoring activities in the basin include the following:

- Ontario Power Generation has implemented a voluntary coal, ash and flue gas sampling and analysis program to support development of the Canada Wide Standard for mercury emissions from coal-fired power plants.

- Red Cliff Reservation has a Surface Water Quality Monitoring Program which tests 21 different locations on the reservation for 22 different parameters including mercury, dioxin 2,3,7,8-TCDD, PCBs, toxaphene, and chlordane. Keweenaw Bay, Grand Portage, Fond du Lac, and Bad River Reservations currently have in place or are developing similar surface water quality monitoring programs.

- In 2003, Western Lake Superior Sanitary District sampled the St. Louis River (11 sites) and four Duluth streams for mercury, dissolved mercury, methyl mercury, and a number of other parameters that usually correlate with mercury concentrations in water. The sample locations also included three tributaries.

- Fond du Lac Reservation conducted a second sediment assessment project funded through GLNPO, sampling St. Louis River sediments and expanding the sediment quality database (particle size, percent solids, loss on ignition, total mercury, methyl mercury, lead, PCBs, toxicity tests).

- Researchers from the University of Wisconsin in LaCrosse and Madison as well as Lake Superior University in Michigan, examined the distribution and fluxes of total and methyl mercury in Lake Superior. They found low concentrations of total mercury (about 0.5 ng/L) in the open waters.

- In Minnesota and Wisconsin, fish consumption advice changed in 2002 so that instead of keeping all coho at the one meal per week level, the less than 18 inch coho are now unlimited and the larger than 18 inch coho are one meal per week. In 2003, the size cut-off for going from one meal per week to one meal per month for chinook went from 22 inches in 2002 to 25 inches in 2003. Lake herring advice changed from unlimited to all sizes one meal per week. The advice is based on both PCB and mercury levels.

- Michigan evaluated fish tissue data and removed the consumption advisory for mercury in ciscowet lake trout although the levels are still too high for chlordane, PCBs and dioxin.

- There have been no changes to the number of sport fish consumption advisories issued in Ontario based on mercury concentrations in fish caught in Lake Superior.

- The Great Lakes Indian Fish and Wildlife Commission drafted a summary of chemical contamination in Lake Superior for the Great Lakes Fishery Commission State of Lake Superior Conference report.

- Temporal and spatial trends of mercury in fish from Lake Superior are being evaluated. Mercury was recently added to the list of analytes measured as part of the GLNPO trend monitoring program. Results of ongoing studies of fish from the Apostle Islands in Wisconsin will also be evaluated for mercury trends.

- The Town of Delta in Bayfield County, Wisconsin received a Wisconsin Great Lakes Protection Fund grant to investigate mercury levels in soil at their abandoned town dump. The Town also hired a contractor to develop an erosion control plan at the site, which sits on a tributary to Lake Superior.

- As of 2004, Bad River Reservation will be monitoring for total and methyl mercury in wet precipitation as part of its ongoing total suspended particulate (TSP) monitoring.

Regulations for the release, control and management of mercury and mercury bearing products are in place in all Lake Superior jurisdictions. New regulations since 2002 are listed below:

- Ontario *Regulation 196/03* came into effect in November 2003 requiring that all dental offices, in which dental amalgam is placed, repaired or removed to have a properly installed dental amalgam separator. The separators are required to meet or exceed the ISO standard for these devices.

- In late 2002 Ashland, Wisconsin passed an ordinance banning the sale of products containing over 50 mg of mercury (with the exception of dental amalgam). The ban does not apply to fluorescent lights since they contain less than 50 mg mercury. Ashland's ordinance also requires mercury-containing devices to be removed from buildings prior to demolition. Superior, WI banned fluorescent lights from landfills in 2002. The City and Douglas County had banned the sale of mercury thermometers in 2001.

4.2.2 PCB Strategies and Related Activities

A variety of voluntary PCB reduction activities in the Great Lakes and Lake Superior have already taken place or are underway. Due to the technical differences in reporting PCB use and storage between Canada and the United States, a binational inventory is not feasible at this time. Reduction data will be reported separately in the forthcoming LaMP 2005 Chemical Milestone report.

Revised Regulations for chlorophenol use and PCB storage in Canada are targeted for publication in 2004. Strict phase-out dates for PCBs are proposed as follows:

- high level (>500 ppm) in-use PCBs by the end of 2007;
- low level (50-500 ppm) PCBs in-use by 2014;
- all PCBs in storage by the end of 2009 and allow in-use PCBs to be transferred to storage for only one year or less;
- all PCBs in sensitive locations within three years of the regulation coming into force; and
- decontamination of all out of service liquids containing less than 2 ppm (the current limit is 50 ppm).

In Ontario, PCB phase-out activities are proceeding in advance of the federal regulations:

- A canvass of seven pulp and paper mills on the north shore of Lake Superior revealed that three mills (Marathon Pulp, Smurfit Stone and Norampac) are entirely PCB-free and the remaining four are phasing out their in-use and in-storage PCBs.

- Algoma Steel Inc. in Sault Ste. Marie, under its Environmental Management Agreement has destroyed 83 percent of its PCB inventory including 100 percent of bulk liquids, 98 percent of capacitors in storage and 50 percent of transformer carcasses.

- In the past three years the City of Thunder Bay has removed and destroyed 2,840 kilograms of PCB transformer oil and cleaning liquids together with 22,650 kilograms of PCB-containing capacitors and street-lighting ballasts. The city is now considered PCB-free**.**

In Minnesota, the MPCA has evaluated transformer inventories at several utilities in the basin. Inventories at one municipal utility and three rural electric cooperatives indicate roughly 700 transformers have a moderate to high risk of containing PCBs. The next phase of the project is to remove as many of the transformers as possible, starting with those that are closest to waterbodies.

Minnesota Power (MP) has removed all of its high-level PCBs except for two PCB capacitor banks, removing over 2500 PCB capacitors since 1994. The two remaining PCB capacitor banks are to be removed during the third quarter of 2004. MP had already removed all of its known PCB transformers and sources of PCB oil of 500 ppm. MP also continues to remove its PCB-contaminated oil in electrical equipment.

4.2.3 Dioxin, HCB, OCS Strategies and Related Activities

Since hexachlorobenzene (HCB) and octachlorostyrene (OCS) can be formed together with dioxin in combustion, these three substances are dealt with as a single group. Projects to identify and reduce sources of dioxin range in scope from an entire state or province to local efforts. Examples of dioxin activities since LaMP 2002 include the following:

Logo for Lake Superior Canadian north shore household garbage burning campaign
Credit: EcoSuperior.com

- EcoSuperior continues a garbage-burning awareness campaign with the support of Environment Canada and the Ontario Ministry of the Environment. Phase 1 of the campaign was a workshop in 2002 hosted by the Lake Superior Binational Forum entitled *Burning Household Garbage: Impacts and Alternatives*. The workshop targeted a diverse group of individuals and agencies and received feedback on behaviors and alternatives regarding burning household garbage. Phase 2 has been a media campaign, outreach to schools, and presentations to community groups and elected politicians. Flyers, bags and tags have been produced for a Parks campaign to begin in 2004.

- Wisconsin Environmental Health Association and Wisconsin Department of Natural Resources (WDNR) produced the *Air Defenders: The Quest for Clean Air*, an educational program about open burning, air quality and asthma for children 10 years and older. The kit includes a CD of an interactive education game, posters, brochures, a WDNR video called *Give Burn Barrels the Boot* and a CD with music lyrics for songs such as *The Burn Barrel Blues*.

- Western Lake Superior Sanitary District in Duluth, Minnesota conducted a second open burning survey, targeting local government officials in Minnesota, Wisconsin and Michigan.

- Superior, Wisconsin continues burn barrel outreach activities and Northwest Wisconsin Regional Planning Commission is developing a burn barrel education video for local officials.

- Environment Canada has conducted stack tests of various dioxin sources including two Kraft mill boilers in the basin (Norampac and Marathon) and crematoria and waste incinerators in other locations. Test results are pending and will be used in calculating the Lake Superior dioxin inventory.

- The Great Lakes Indian Fish and Wildlife Commission has an ongoing study that is collecting baseline dioxin and furan concentrations in common tribally harvested fish species from several locations in Lake Superior (lean lake trout, siscowet trout, lake whitefish, and lake herring).

- Red Cliff Reservation continued its Burn Barrel Elimination Program and to date has collected more than 100 burn barrels.

- Bad River Reservation expanded a burn barrel outreach effort, including the use of the new materials developed by the Wisconsin Environmental Decade and Wisconsin Department of Natural Resources.

- Grand Portage Reservation hired an air quality specialist to identify air quality issues and develop projects to minimize effects, including dioxin from burn barrels.

- Fond du Lac Reservation is beginning a burn barrel initiative.

- EcoSuperior is involved in local promotion of the national Burn-It Smart Campaign to reduce emissions from woodstoves and similar appliances.

- University of Wisconsin Lake Superior Research Institute has a project funded by U.S. EPA GLNPO to update the dioxin inventory for the Lake Superior basin.

4.2.4 Pesticide Strategies and Related Activities

Various jurisdictions in the basin continue to carry out “clean sweep” collections of remaining stockpiles of banned pesticides from farmers and commercial applicators and to educate residents about their proper disposal. Household hazardous waste collections also continue in the basin. In the United States, tribal governments continue to conduct household hazardous waste collection and education activities within reservation boundaries as well as in surrounding communities. The most recent pesticide collection under the Ontario Clean Sweep program was conducted in 2001. The provincial government treats these materials as hazardous wastes and they are either disposed to a secure landfill or incinerated at approved facilities with the ash landfilled. Ontario remains committed to the program; however, this costly program is not conducted every year.

Collection activities include the following:

- Provincial and state waste pesticides collections continue. Table 3 shows the amounts collected since the LaMP 2002. The table also shows earlier data not previously reported by the LaMP. It should be pointed out that the pesticides targeted for zero discharge are still being found in the basin.

Table 3. Recent Waste Pesticides Collected in the Lake Superior Basin (kg)

Jurisdiction	Dates of Collection	Aldrin/ Dieldrin	Chlordane	DDT	Silvex/ 2-4D/ 2,4,5T	Toxaphene	Total Pesticides[1]
Michigan[2]	9/02-10/03						434
Minnesota[3]	1999-2003	28	241	752	4145	17	15,978
Ontario[4]	2002-2003						599 kg of solids and 1348 litres of liquids
Wisconsin[5]	1999-2003	0	39	36	89	0	8,682

[1] Total of all pesticides collected.
[2] Data from the Michigan Department of Agriculture compiled by the Michigan Department of Environmental Quality for counties in the Upper Peninsula.
[3] Compiled by Minnesota Department of Agriculture Waste Pesticide Collection Program for Carlton, Cook, Lake and St. Louis Counties.
[4] Data from municipal collections in Thunder Bay, Manitouwadge and Marathon.
[5] Data from the Northwest Wisconsin Regional Planning Commission compiled by the Wisconsin Department of Natural Resources for Ashland, Bayfield, Douglas and Iron Counties.

- In Wisconsin's part of the basin, collections for hazardous waste from households, small businesses, and agricultural operations is conducted through a mobile collection program operated by Northwest Wisconsin Regional Planning Commission. In 2002, the program expanded to provide "milk run" collections for small businesses to make proper disposal of hazardous waste more affordable in this rural area. The community based pollution prevention projects in the basin, including the Northwest Wisconsin Mercury Free Schools, utilize this collection program.

- In 2003, EcoSuperior held the first ever household hazardous waste collection collections in the towns of Marathon and Manitouwadge. One hundred and sixty litres of pesticides were among the hazardous materials collected.

- Between 1999 and 2003, the City of Thunder Bay collected 599 kilograms of solid pesticides 2,236, litres of liquid pesticides, 118 kilograms of mercury through its household hazardous waste program. During 2002 and 2003, 288 litres of pharmaceuticals were collected.

- Bad River Reservation is conducting an assessment of water, sediment and wild rice plant grains for residuals of the chemical treatment used for invasive species.

- Grand Portage Reservation is currently implementing a Pesticide Use Policy on the Reservation to help avoid unnecessary and unscrupulous spraying.

4.2.5 Contaminated Sediment and Stormwater: Sources of Lakewide Remediation Chemicals

In addition to the nine pollutants included in the Lake Superior Zero Discharge Demonstration Program, the LaMP process identified other critical pollutants for Lake Superior which impair beneficial uses or which are found at levels that exceed criteria set to protect the Lake's ecosystem. Although these critical pollutants are not slated for zero discharge and do not have associated load reduction targets, their LaMP management goal is pollutant reduction so that beneficial uses are restored.

"Lakewide remediation" is a category of critical pollutants which exceed criteria levels in the open lake or are found in several contaminated sediment locations around the basin. These chemicals also could pose a risk to Lake Superior based on their toxicity and other chemical properties. Three of the lakewide remediation pollutants: heptachlor, alpha-BHC and alpha endosulfan exceeded criteria in open lake waters. Sources of these pollutants are primarily long-range transport. Cadmium and Polynuclear Aromatic Hydrocarbons (PAHs) on the other hand, are lakewide remediation pollutants with sources in the basin. They are found in multiple contaminated sediment areas as well as in stormwater runoff. PAHs in particular cause multiple impacts in the Lake Superior basin. The presence of these pollutants in contaminated sediment and stormwater runoff is important to the Lake Superior ecosystem because they impact its most biologically productive region.

Lake Superior has a narrow rim (less than 5% of its area) of shallow nearshore area and embayments that comprise its most biologically productive area. Most species of Lake Superior fish use the nearshore waters for some critical life stages. The nearshore and embayments are the areas most impacted by contaminated sediment "hot spots" and by stormwater runoff carrying contaminants from industrial and developed areas.

Contaminated Sediment

Contaminated sediments are a concern in many of the Lake Superior Areas of Concern (AOCs) and several other areas of localized contaminated sediment and soils. Some of the zero discharge pollutants are found in Lake Superior AOC sediments. In addition, PAHs are a problem in some Lake Superior AOCs and at other sites. They are commonly found in relation to developed areas from street runoff and at higher concentrations in association with old industrial sites. Stormwater runoff from industrial and commercial sources can serve as a source of PAH contamination to sediment. In the Lake Superior basin, concentrated areas of PAHs in sediment are mainly related to past dumping of industrial wastes from steelmaking, coking, petroleum refining and shipment, wood preserving, coal shipment, and coal gasification for "gas lights" in the late 1800s and early 1900s. Contaminated sediment activities since the LaMP 2002 include the following:

Thunder Bay Harbour, Ontario
Credit: Patrick Morash, Ontario Ministry of Environment.

- In Thunder Bay Harbour the cleanup and remedial measures at the Northern Wood Preservers site have been completed. Approximately 13,000 m^3 of creosote-contaminated sediment was dredged from the harbour areas around the Northern Wood Preservers site and treated off-site by thermal desorption. An additional 21,000 m^3 of contaminated sediment was contained within the confines of a rockfill berm and capped with clean fill. The contaminant source was isolated using a steel sheet pile wall. Monitoring programs are now underway to assess that the barrier and groundwater control systems effectively prevent the remaining on-shore contaminants from moving toward Lake Superior. A naturalized buffer was created between the industrial site and the harbour. Studies will be undertaken in 2004 and in later years to document the changes in fish habitat and to assess natural recovery of low impacted sediment remaining outside of the rockfill berm.

- Wisconsin Department of Natural Resources (WDNR) removed 7500 cubic yards of PAH contaminated sediment and floodplain soils during the summer of 2003 from Newton Creek in the St. Louis River Area of Concern. Newton Creek flows through residential neighborhoods of Superior, WI into Hog Island Inlet of Superior Bay. Funding for this project was provided through the U.S. EPA Great Lakes National Program Office, Wisconsin Coastal Management Program, WDNR Harbors and Bays and Remediation programs. WDNR will seek funding to remediate contaminated sediment in Hog Island Inlet and restore this valuable shallow water and wetland habitat, which lies 1.5 miles from the confluence of the St. Louis River through Superior Bay to Lake Superior.

- The St. Louis River Citizens Action Committee is facilitating an updated contaminated sediment strategy focused on PAHs in the Area of Concern, coordinated between Wisconsin and Minnesota. Start-up funds are from the Wisconsin Department of Natural Resources.

- Under direction from the Minnesota Pollution Control Agency, the responsible party at the US Steel site in Duluth has recently completed two investigations of St. Louis River sediments. In March 2002, the Laser

Induced Fluorescence tool was used through the ice to profile coal tar waste across 80 acres of sediments in Spirit Lake. Sediment samples were collected with a barge mounted geoprobe in September 2003 to confirm the Laser results against analytical results. The Agency will be evaluating this data in the next few months.

- One of the two federal Superfund sites in the St. Louis River Area of Concern, the former Interlake/Duluth Tar site, is nearing a Record of Decision between the Minnesota Pollution Control Agency and the responsible parties. Remedial operations (a combination of dredging and capping) should begin in spring 2004.

- Wisconsin Department of Natural Resources, U.S. EPA, and responsible parties continue to investigate the Ashland – Waterfront Superfund site in Ashland, Wisconsin. Groundwater contamination and PAH contaminated sediment in a ten-acre area of the Ashland waterfront result from historical operation of a coal gasification plant.

- The Minnesota Pollution Control Agency carried out a sediment remediation scoping project in Minnesota Slip using funding from U.S. EPA GLNPO. PAHs, PCBs, lead, mercury and zinc were analyzed and results showed contamination within the slip is heterogeneous. The greatest exceedance of sediment standards occurred with PAHs. An extensive sediment investigation was initiated in March 2004.

- The Minnesota Pollution Control Agency developed a GIS-based contaminated sediment database for the St. Louis River Area of Concern with funding from U.S. EPA GLNPO. Funds are being sought from the Wisconsin and Minnesota Coastal Management Programs to complete the project.

- In Ontario, federal and provincial officials are in the processs of undertaking scientific reviews and considering management options for three Areas of Concern. At the Peninsula Harbour AOC, staff have assembled the necessary data on sediment conditions and and will determine if there would be an overall environmental benefit from removing contaminated sediment from the harbour. At the Thunder Bay AOC, studies are underway adjacent to the Cascades Fine Papers Group Thunder Bay, Inc. to complete the sediment assessment and determine the need for remediation. At the St. Marys AOC a sediment management strategy is being developed.
- The Minnesota Coastal Program granted $445,000 to the City of Duluth for remediation at the Sargent's Creek Dump Site. This is a clean-up project at a dumpsite on the banks of a tributary to the St. Louis River estuary.
- A coal tar site on the lake shore at Burlington Bay in Two Harbors, Minnesota is being investigated to determine the extent of PAH contamination. It is not certain yet if sediments are impacted.

- A Reserve Mining unpermitted landfill in Silver Bay, Minnesota contains over 1000 barrels of leaded grease that is considered hazardous waste. Some lead and other heavy metals were found in small creeks down gradient from the landfill. It has not been determined if the contamination has reached Lake Superior.

- PCBs were found in sediments of Kingsbury Creek near the DM&IR site in Proctor, Minnesota. Kingsbury Creek is a tributary of St. Louis River, although it is some distance from the lake.

The Lake Superior Stormwater Project

From 1993 to 1995, the Lake Superior Binational Program engaged in a project to investigate the importance of stormwater as a pollutant source in the Lake Superior basin. Most urban storm runoff was delivered to the lake untreated, by way of ditches and storm sewers that flow into the lake or to tributary streams. This project was a partnership of Wisconsin, Minnesota, Michigan, the U.S. Geological Service and U.S. Environmental Protection Agency. The project focused on municipalities with populations greater than 5,000: Superior, Ashland, and Hurley, Wisconsin; Duluth, Hibbing, Virginia, and Cloquet, Minnesota; Marquette, Houghton/Hancock, Ishpeming, Sault Ste. Marie, Negaunee and Ironwood, Michigan. Project staff estimated the amounts of stormwater pollutants entering Lake Superior, developed best-management practices for reducing contaminated runoff from bulk storage piles, conducted an information campaign about stormwater pollution, and assisted communities in stormwater planning. Samples of water from rain and melting snow were taken from streets, rooftops and storm sewers. Heavy metals and PAHs in storm sewers were typically at concentrations exceeding the allowable limits in point source discharges. Total loading of PAHs to the lake from storm sewers in urban areas on the U.S. side of the basin was calculated at 550 kilograms/year.

In the years following the 1995 end of this project, stormwater-permitting requirements have been put forward by the U.S. EPA for larger communities. The Lake Superior stormwater project helped lay the foundation for stormwater planning and controls in Duluth, Minnesota, Superior, Wisconsin and Marquette, Michigan. U.S. EPA's next phase of stormwater regulations will extend requirements for erosion control and on-going stormwater management to industries and activities where over one acre of land is disturbed. While these new requirements will help the Lake Superior environment, they create a huge need for education. Following are several recent projects to address those needs.

- The Village of LaPointe, Wisconsin has a stormwater demonstration project at a commercial development near the Madeline Island waterfront funded by Wisconsin Coastal Management.

- The U.S. Army Corps of Engineers is proposing to provide environmental assistance to the City of Two Harbors, MN to construct a 2.5 million gallon stormwater detention basin at their wastewater treatment plant. Currently, untreated sewage is dumped into Lake Superior during overflow storm events. Pending approval from the MPCA, plans are to have the system operational by Dec. 2004. The basin is being designed to contain up to a 25-year storm event and the estimated cost in excess of $US 2 million.

- Recent Minnesota Pollution Control Agency enforcement actions were responsible for two stormwater projects, including Lutsen Mountain Inc. installing erosion control measures on steep slopes and Lake County installing a storm water basin in Two Harbors for flood and pollutant control on Skunk Creek.

Sediment in Poplar River, Minnesota
Photo by Jesse Anderson, Minnesota Pollution Control Agency

- The Minnesota Coastal Program granted $350,000 to Cook County to complete flooding and erosion control projects in the Grand Marais area, including erosion control and restoration on Village Creek and in the Creechville area.

- The Northland Nonpoint Education for Municipal Officials (NEMO) network serves as a way to coordinate watershed and stormwater education in the basin. Partners include University of Wisconsin – Lake Superior Research Institute and Minnesota Sea Grant.

- Wisconsin Department of Natural Resources and University of Wisconsin-Lake Superior Research Institute have a watershed education and stormwater outreach project to reach local officials and developers on the reasons for stormwater management to protect Lake Superior watersheds and fisheries (funded by WI Great Lakes Protection Fund).

- Superior, Wisconsin has a stormwater planning and education project. The local schools participate in educational events and have stenciled storm sewer covers with the message "Dump No Waste- Drains to Lake." The City also offers assistance to local homeowners for water management and has set up demonstration rain gardens and rain barrels. Wisconsin Great Lakes Protection Fund and the Great Lakes Commission have funded this work. The City is seeking funding for stormwater retention and treatment basins.

- The Minnesota Coastal Program granted $84,000 to the Lake County Forestry Department to develop methods of forest management that improve water quality in nearby streams. Projects include northern hardwoods management and conifer restoration.

- The Minnesota Pollution Control Agency annually participates in the Arrowhead Builder's Association's continuing education workshops and the Associated General Contractor's Duluth Safety Day by providing proper stormwater management information to attendees.

- The Minnesota Pollution Control Agency helped form the Regional Stormwater Protection Team and now actively participates as a member. The Team's mission is to protect and enhance the region's shared water resources through stormwater pollution prevention by providing coordinated educational programs and technical assistance. Members include; the City of Duluth, City of Hermantown, City of Proctor, Duluth Township, Midway Township, Rice Lake Township, UMD, St. Louis County, MnDOT, City of Superior and the South St. Louis Soil and Water Conservation District.

4.3 PUBLICATIONS LIST

Partners in the Lake Superior Binational Program have produced a variety of recent publications concerning zero discharge chemicals. They range from open burning videos to proceedings from the *Mercury in Our Lives* workshop to various posters, flyers, cards and reports. Appendix C lists these new source materials, along with contact information.

4.4 LaMP CHEMICAL MILESTONE REPORT

The chemical milestone report will serve as a comprehensive update and revision of the LaMP 2000 report (formerly Stage 3 LaMP) for Lake Superior critical chemicals. As set in the LaMP Stage 2, 2005 is a milestone year for the Lake Superior load reduction schedules for both the PCBs and dioxin. Using 1990 as a baseline year, the LaMP Stage 2 targets a 60% reduction for PCBs and an 80% reduction for dioxin, HCB and OCS in 2005. The Lake Superior Chemical Committee will assess progress towards these targets in the LaMP Chemical Milestone Report. Progress may be difficult to report given the weakness of the inventories for PCBs and dioxin. The committee will also update the mercury inventory and assess pesticide collections, although neither has a 2005 target. In attempting to meet milestones, the Chemical Committee is developing new indicators to measure success.

Another significant part of the report will be the evaluation of the LaMP 2000 strategies (Table 2) and associated reduction activities together with recommendations to update them. This work will be conducted with the assistance of the Lake Superior Binational Forum. In addition, the committee will examine the status of emerging chemicals and their relevance to the Lake Superior basin.

The sustainability theme will not be neglected in the 2005 milestone report. For example, although closures of industrial facilities eliminate discharges and emissions to the environment, the social and economic consequences to small communities are often of major proportions. In addition, the purchasing decisions and behavioral changes of citizens together with municipal or county level policies are key to ensuring progress to zero discharge.

Appendix A. Contaminant Trends in Lake Superior Herring Gull Eggs 1974-2002[4]

Herring Gull eggs have been collected and analyzed annually from the same two Lake Superior sites since 1974. Current (2002) concentrations of Zero Discharge pollutants from the Agawa Rocks and Granite Island sites ranged as follows (all values are wet weight): PCBs as 1:1, Aroclor 1254:1260, (6.07 6.59 ug/g), PCBs as sum of congeners, (2.88 – 3.22 ug/g), chlordane (0.0766 – 0.0826 ug/g), DDE (1.13 – 1.23 ug/g), dieldrin (0.027 – 0.040 ug/g), HCB (0.009 – 0.010 ug/g), TCDD (3.38 – 4.26 pg/g) and mercury (0.163 – 0.167 ug/g). For the Lakewide critical pollutant heptachlor epoxide the range was 0.022 – 0.026 ug/g, and for the Prevention pollutant mirex the range was 0.020 – 0.021 ug/g.

The annual data from both sites, 1974-2002, were analyzed by change point regression (Pekarik and Weseloh 1998). Figure 1 illustrates trends in selected pesticides. At Agawa Rocks, total chlordanes have declined by 66.8% from 1987 to 2002. At Granite Island, total chlordanes have declined by 78.0% from 1987 to 2002. At both sites, dieldrin and heptachlor epoxide were declining faster now than they did earlier in the study. (See paragraph below for a further discussion of these two chemicals.) DDE and PCBs have declined at a constant rate throughout the study at Granite Island but their rates of decline have slowed in recent years at Agawa Rocks. HCB and mirex showed just the opposite pattern; they have declined at a constant rate at Agawa Rocks but declined more slowly in recent years at Granite Island. TCDD has declined faster recently at Agawa but shows no trend at Granite. In summary, 64.3% of contaminant-colony comparisons are declining as fast as or faster now than they were earlier in the study, while 28.6% have declined more slowly in recent years.

In terms of spatial patterns among the 15 Herring Gull Annual Monitoring sites from throughout the Great Lakes, data for 1998-2002 show that for dieldrin and heptachlor epoxide, gull eggs from both Granite Island and Agawa Rocks were among the most contaminated sites, ranking 3rd and 4th most contaminated, respectively, for each (Figure 2). For most other compounds, DDE, HCB, mirex, PCBs, TCDD and Hg values from the two sites did not differ from sites whose values were in the lower half of the overall range.

[4] Canadian Wildlife Service, Environment Canada.

Fig 1a. Dieldrin in Herring Gull eggs, Agawa Rks., 1974-2002

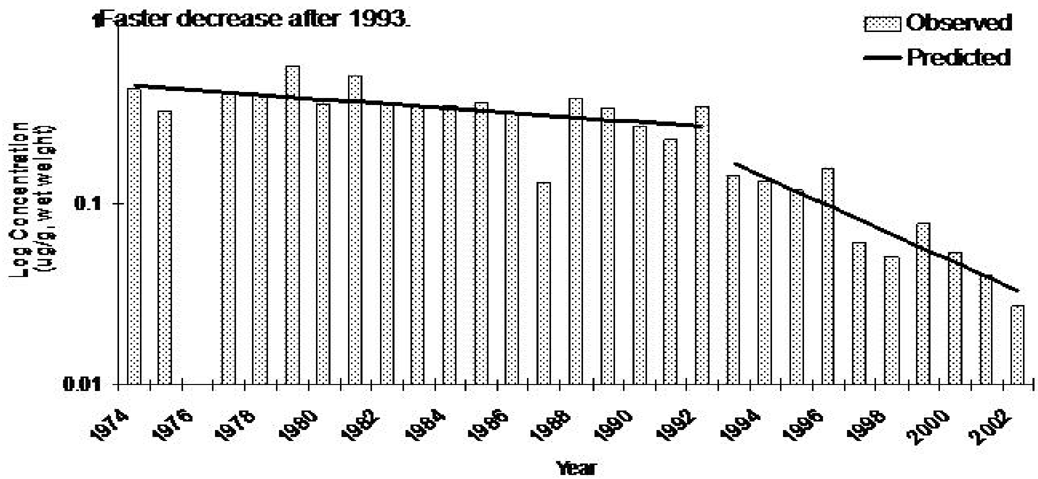


Fig 1b. Heptachlor epoxide in Herring Gull eggs, Granite I., 1974-2002

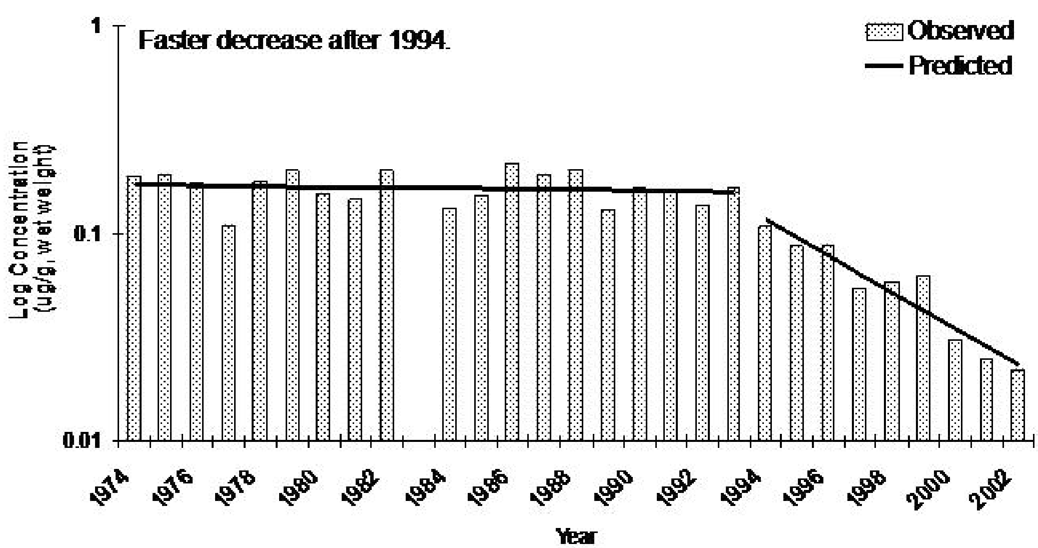
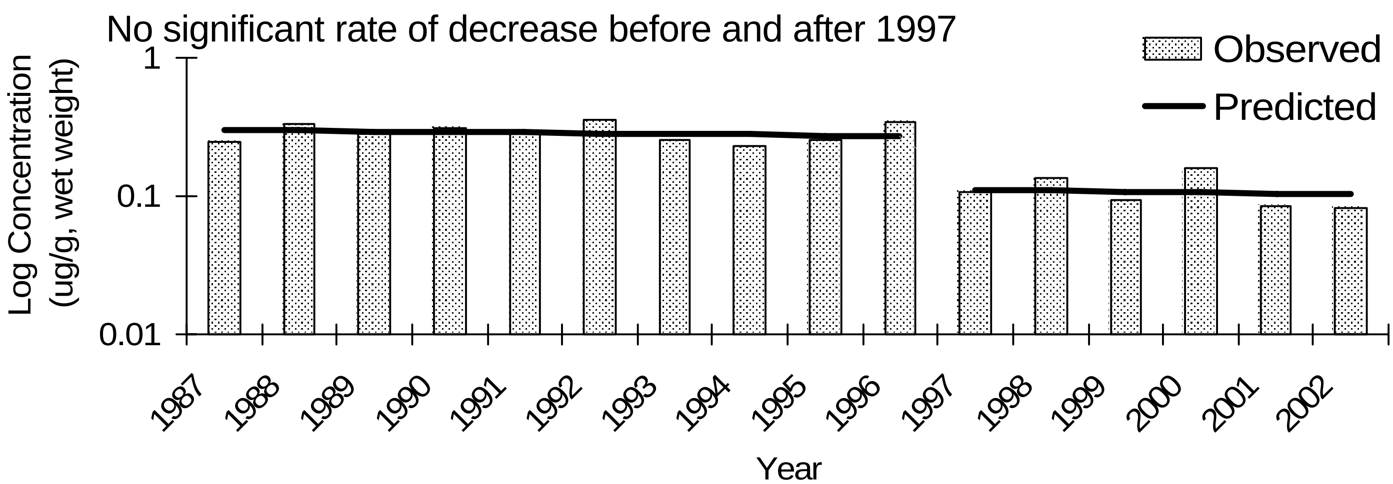
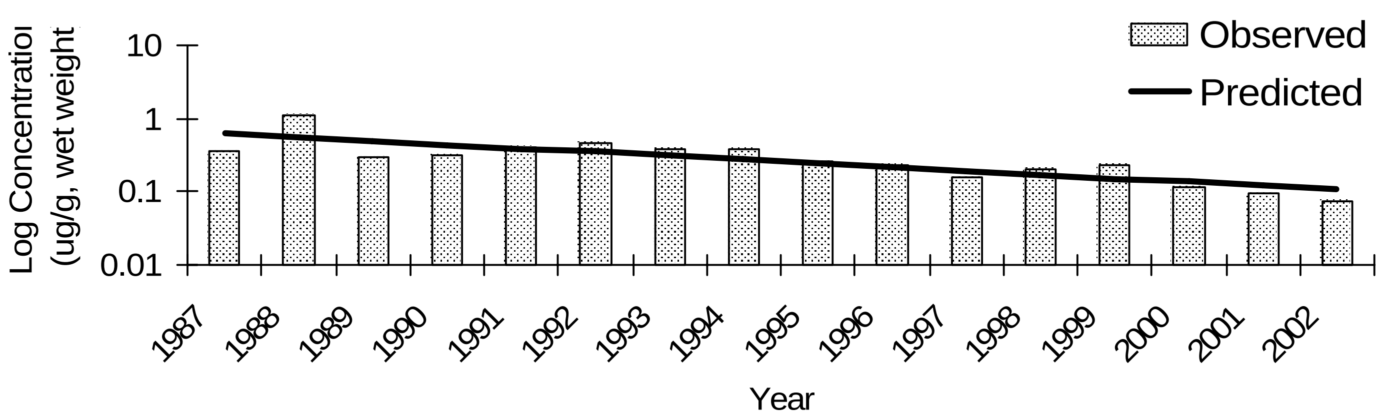


Fig 1c. Total chlordane* in Herring Gull eggs, Agawa Rocks, 1987-2002
*Total chlordane = oxychlordane, cis-chlordane, transchlordane, cis-nonachlor and transnonachlor



The average concentration of total chlordanes from 1987-2002 was 0.2219 ug/g of which 55.3% was oxychlordane, 22.0% was transnonachlor, 20.4% was cisnonachlor, 2.2% was cischlordane and 0.1% was transchlordane.

Fig 1d. Total chlordane* in Herring Gull eggs, Granite I., 1987-2002
*Total chlordane = oxychlordane, cis-chlordane, transchlordane, cis-nonachlor and transnonachlor



The average concentration of total chlordanes from 1987-2002 was 0.3220 ug/g of which 43.5% was oxychlordane, 35.9% was transnonachlor, 18.0% was cis-nonachlor, 2.3% was cis-chlordane and 0.3% was transchlordane.

Figure 2a. Spatial patterns for mean dieldrin (±S.D.) values, 1998-2002, among the 15 Herring Gull Annual Monitor Colonies. Means with the same letter are not significantly different (SNK test).

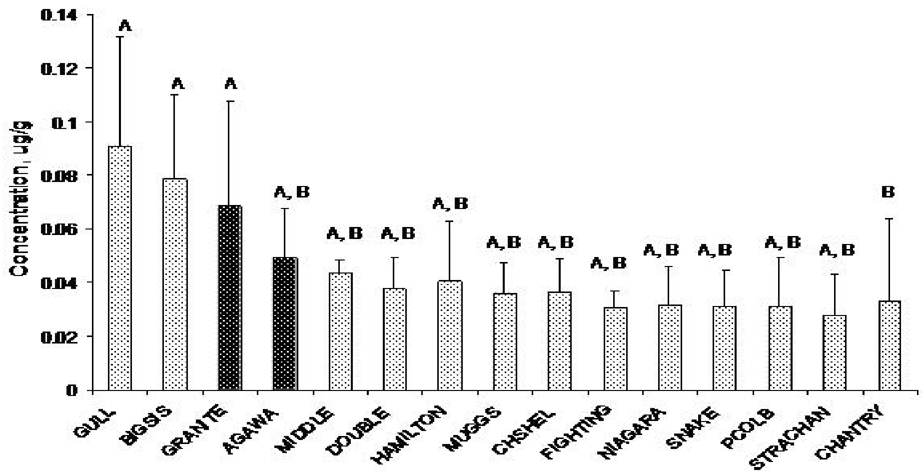
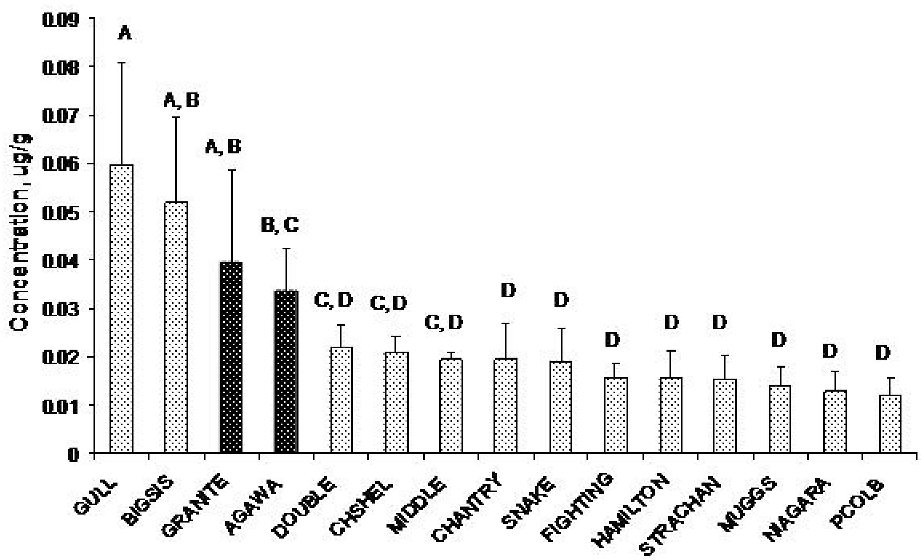


Figure 2b. Spatial patterns for mean heptachlor epoxide (±S.D.) values, 1998-2002, among the 15 Herring Gull Annual Monitor Colonies. Means with the same letter are not significantly different (SNK test).



Appendix B. Lake Superior Forum Chemical Committee 2003 Activities

Joint Projects with Lake Superior Workgroup agencies:

- The committee undertook the following three joint projects: mercury outreach, burn barrel outreach and abandoned white goods.
- The effects of mercury on human health and mercury source awareness are potential future joint projects.

Mercury Issues/Mercury Workshop, June 2003

- The committee provided strategic advice and support on mercury outreach; assisted in organizing the mercury workshop in Thunder Bay.
- The committee sent a letter to the Binational Executive Committee (BEC) requesting an update on BEC's advocacy role for regulatory actions to achieve mercury load reduction targets for Lake Superior.
- As a follow up to the mercury workshop, the committee will pursue ideas on how to implement mercury bans in local communities and institutions including schools, universities/colleges and hospitals.
- The committee drafted a letter to Lakehead University and Confederation College asking how they deal with mercury from their laboratories and to identify mercury problems around campus.

Mining

- Newmont Mining requests Forum feedback on the "Toward Sustainable Mining" (TSM) initiative of the Mining Association Canada (MAC). A subcommittee was formed to review and comment on the initiative.
- The committee drafted a letter of approval to Newmont Mining for the TSM initiative and asked to be allowed to review and provide input into further documents.

LaMP-related activities

- The committee and SWG agreed to hold a monthly conference call and a yearly joint meeting to assess the progress of goals set for the reduction of critical pollutants and additional chemicals.

Contacts: Barb Nicol (Canada) barb.nicol@lakeheadu.ca
Lissa Radke (U.S.) lradke@northland.edu

Appendix C. Publications and Outreach Materials Associated with the Lake Superior LaMP: 2002 and 2004

Air Defenders: teaching kit on burn barrels and respiratory disease developed by Wisconsin Environmental Health Association and Wisconsin Department of Natural Resources. Contact: Lindsay Haas, www.airdefenders.org

Burn Barrels: Unhealthy, Unneighborly, Unnecessary and Illegal: Burn barrel education leaflet produced by University of Wisconsin – Extension. Contact: David Liebl

Burning Garbage EcoNews: Radio and Television advertising running in segments on Thunder Bay outlets from September 2002 to March 2004.

Burning Garbage Makes Poison: Poster produced by EcoSuperior and Environment Canada. Contact: Jane Oldale, www.ecosuperior.com/openburning.html

Burning Household Garbage: Impacts and Alternatives: Workshop Summary April 2002. Contains workshop conclusions, breakout session Questions and Answers, speakers slides. Contact: Barb Nicol,

Burning Household Garbage outreach: materials produced by EcoSuperior to date: tax bill inserts; woodstove retailer tags; and (in parks) campfire flyers, tags for firewood bundles, and garbage/litter bags. Contact: Jane Oldale www.ecosuperior.com/openburning.html

Dental Wastes Best Management Practices guide for the dental community: prepared by the Royal College of Dental Surgeons of Ontario. www.rcdso.org/pdf/dental_wastes/dental_amalgam_mercury.pdf

***Don't Burn Trash at Your Campsite**:* a card for distribution at campsites produced by the Minnesota Pollution Control Agency with assistance from other agencies. Contact: Carri Lohse-Hanson

Fish Contaminant Monitoring Program Report: Report from Michigan Department of Environmental Quality shows that contaminant concentrations declined between 1991 and 2001 in Lake Superior lake trout. Contact: Bob Day

***An Historical Overview of Mercury: Lake Superior Perspective**:* Poster produced by the Lake Superior Binational Program Chemical Committee for the IJC mercury workshop that documents mercury reductions since 1990. Contact: Patrick Morash

Lake Superior 2004: A Year of Protecting the Greatest of Lakes: Calendar produced by St. Louis River Citizens Action Committee, Minnesota Pollution Control Agency, Wisconsin Department of Natural Resources and other partners. Paper supplied by Sappi Fine Papers. Contacts: Carri Lohse-Hanson and Nancy Larson

Lake Superior Basin Plan: Examining the Health of Watersheds (draft): Report defines goals and strategies for water resource management for the Minnesota portion of the basin, produced by the Minnesota Pollution Control Agency. Contact: Brian Fredrickson

Mercury in Our Lives: A Workshop on Mercury Reduction for the Lake Superior Community: Speakers' slides and proceedings from a workshop held in June 2003. Contact: Barb Nicol

Mercury Reductions via Public/Consumer Outreach: A report produced for the St. Louis River Watershed TMDL Pilot Project by Barr Engineering. Contact: Paula Jackson

Mercury Use Tree: Sources and Common Uses: An updated poster version of the Stage 2 use tree produced by the Minnesota Pollution Control Agency. Contact: Carri Lohse-Hanson

Open Burning: A survey to assess health, environmental, legal, enforcement and safety issues concerning open burning in our region: Survey of local units of government in portions of Minnesota, Wisconsin and Michigan regarding health, environmental, legal, enforcement and safety concerns related to open burning of household trash. Produced by Western Lake Superior Sanitary District. Contact: Doug Fairchild

Open Burning And Backyard Dumping: Report and Recommendations of the Stakeholder Steering Group: Report from Wisconsin stakeholders presented to Wisconsin Natural Resources Board. Contact: Kevin Kessler

PCB Use Tree: Sources and Common Uses: An updated poster version of the Stage 2 use tree produced by the Minnesota Pollution Control Agency. Contact: Carri Lohse-Hanson

re: amalgam recovery: Booklet for dentists produced by Minnesota Dental Association and the Metropolitan Council. Contact: Loren Hanson

Review of the Status and Trends of Lake Superior Environmental Chemical Contamination in Air, Water, and Selected Biota: Summary of chemical contamination in Lake Superior produced for the Great Lakes Fishery Commission-State of Lake Superior Conference. Contact: Kory Groetsch

Teamwork on Wisconsin's North Coast: Sixteen page article in Wisconsin Natural Resources magazine. Contact: Nancy Larson

We at the MPCA have a nose for trouble: Bookmark showing Clancy the mercury detecting dog produced as part of the Mercury Free Zone project by the Minnesota Pollution Control Agency. Contact: Chris Butler

What Goes Up, Must Come Down. Poster produced by Environment Canada and EcoSuperior on the effects of burning garbage. Contact: Bruce Gillies

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Chapter 4

Lake Superior Critical Pollutants

Pulp Mill Smokestack near Terrace Bay, ON
Photograph by: Patrick T. Collins, MN DNR

Lake Superior Lakewide Management Plan
2000

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EXECUTIVE SUMMARY

Annex 2 of the 1987 amendments of Great Lakes Water Quality Agreement (GLWQA) commits the United States and Canada to a framework for the restoration and protection of beneficial uses through the development and implementation of Remedial Action Plans for specific Areas of Concern and Lakewide Management Plans (LaMPs) for open lake waters. Each LaMP is intended to identify the critical pollutants that affect the beneficial lake uses and to outline the strategies necessary to reduce loadings and restore those uses.

In 1991 the Lake Superior Binational Program (LSBP) was established for the lake in order to restore and protect the basin. The LSBP has a number of ecosystem objectives for the lake including a Zero Discharge Demonstration Project; which has as its primary goal the virtual elimination of the discharge and emission of nine persistent bio-accumulative toxic chemicals. While the LaMP for Lake Superior is formulated under the GLWQA and addresses the requirements of that agreement, the LaMP for critical pollutants also serves to carry out the goals and objectives of the Lake Superior Binational Program.

The Stage 2 Lake Superior LaMP mapped out a 20-year path for zero discharge by establishing load reduction schedules and targets. Stage 3 takes the next step by identifying the reduction strategies and actions needed to achieve the targets. Chapter 4 of the LaMP 2000 satisfies the Stage 3 GLWQA requirements for the Lake Superior LaMP.

Within Section 4.1 the nine chemicals targeted for reduction are organized into four groups: Mercury; PCBs; Pesticides; and, Dioxin, HCB and OCS. The 1990 base line inventories for each group are presented together with a report of the successes to date; and the types of strategies that will be pursued over the next 2 to 3 years to meet interim targets for zero discharge.

Section 4.2 of this chapter identifies the goals, strategies and actions that the binational partners have committed to undertake both individually or collectively for the nine chemicals. Section 4.3 organizes the strategies and actions by sector. Individually the agencies have made over 200 commitments including actions which maybe considered further into the future. Section 4.4 identifies strategies to restore contaminated sites. Section 4.5 outlines monitoring strategies to quantify the results from the proposed LaMP 2000 actions. Section 4.6 is a short summary of the planning and reporting activities which will be undertaken by the partners. Addendum A details the chemical inventories and assumptions which are used for load reduction estimates in Section 4.1.

Highlights

Chapter 4 documents significant improvements in all of the four major critical pollutant categories: Mercury, PCBs, pesticides, and dioxin, HCB and OCS. Although successes have been achieved over the past decade, significant challenges have also emerged for the future. These challenges must be addressed in order to achieve further reductions in some categories and to ultimately protect Lake Superior in the long term.

Releases of the nine designated chemicals have declined since the 1990 baseline year. Reductions have occurred as a result of: voluntary reduction efforts by facilities in the Basin; new competitive technologies and products; facility closures; and Federal, State and Provincial regulations.

Mercury

Significant reductions in mercury use and emissions in the Lake Superior Basin have occurred in the last decade as a result of ore smelting and processing plant closures in both Canada and the United States and a significant decline in mercury content in commercial products The largest contributing sources of mercury are from mercury-bearing products; emissions from the mining sector; and fuel combustion. While significant reductions have been achieved in the use of mercury in commercial products, mercury emissions continue at relatively high levels from mining operations and fuel combustion associated with electrical generation.

The 1999 estimate of 819 kg/yr of on-going mercury releases represents a 66 percent reduction from the 1990 estimate of 2,444 kg/yr. This reduction fulfills the year 2000 LaMP target of 60 percent reduction for mercury releases within the basin.

The major challenge for the long term protection remains the air emissions of mercury from sources both within and beyond the basin.

PCBs

The LaMP reduction goal calls for 100 percent destruction of PCBs in the Lake Superior basin by the year 2020. The concern with PCB reductions within the Lake Superior Basin is not their ongoing release; rather, the prevention of future releases through the removal of PCBs in use and the destruction of PCBs in storage.

Different reporting and classification standards between the two countries for PCB-bearing products remaining in use or in storage, makes it difficult to quantify whether or not the year 2000 target for 33 percent has been achieved. However, a comparison of estimates for products which remain in use or in storage and those which have been destroyed over the past decade, indicate that Canada and the United States are making progress to achieving a 60 percent destruction target set for the year 2005.

The PCBs which remain in storage or in use are within the municipal, utility, mining and industrial sectors. The challenge for regulatory authorities is to facilitate and encourage the continued decommissioning and destruction of PCB stores and equipment to meet the 2005 target.

Dioxin, HCB, and OCS

In 1990, most of the dioxin released to the atmosphere was produced by small incinerators in the U.S. associated with institutional, commercial and residential uses. Since the 1990 virtually all of these small, inefficient incinerators have been phased out, resulting in a very large reduction in dioxin air emissions. Closures of ore processing facilities and medical waste incinerators in both countries have also contributed to significant reductions in dioxin emissions.

The available data for HCB and OSC emissions are too sketchy to confidently predict the change in releases of these pollutants within the Lake Superior Basin since 1990. The available data suggest that the major sources of dioxin, such as incineration, are also sources of HCB and OSC. Until better monitoring data and assessments are available, dioxin trends will substitute for HCB and OSC trends. Estimates for 1999 indicate that reductions in emissions of dioxins are in the range of 75-95 percent. Although a more accurate estimate can not be made as a result of baseline variables, it is clear that significant progress has been made to meet the year 2005 target of 80 percent reduction.

As the major sources of dioxin come under control the new challenges for the future will come from smaller commercial and residential incineration emissions; from continuing long range atmospheric transport; and from commercial products containing trace level dioxin impurities.

Pesticides

The LaMP reduction goal for targeted pesticides is to retrieve and destroy all stockpiles by 2000. Documentation for collections has been inconsistent in the past. Not all collections have been reported by specific pesticide. Stores of these substances likely still remain in the Lake Superior Basin. It is not possible to determine with certainty that all stockpiled pesticides will be accounted for by 2000. Stockpiles of pesticides used in the past for agriculture, silviculture, and household purposes may still be held by residents, or may become orphaned when property is sold. Collection and outreach programs should continue into the future.

The challenges for the future remain: the continuation of collection efforts; the education of the public both within and outside of the basin; and the long term problem of atmospheric transport of pesticides.

Conclusions

As the chapter illustrates, the strategies to achieve future reduction targets are many and varied. Voluntary agreements and cooperative efforts among regulatory authorities and emitters are a common theme for all categories of pollutants. Outreach programs remain key to achieving long term reductions and are central strategies to each group of pollutants. Innovative strategies such as product stewardship and incentive programs are presented. Some regulatory strategies are also proposed for the future.

While the LaMP strategies will lead to further reductions in the near term from sources within the basin, the long term protection for Lake Superior will be dependent on expanding these regional initiatives to pollution sources outside of the basin. The challenge facing both federal governments is to deal with the long range transport of pollutants from outside the basin. All agencies will remain very active within the basin to deal with regional issues. Product stewardship programs and more environmentally benign products need to be addressed comprehensively. Locally partnerships will be required to provide the resources for major restoration projects, to deal with technological gaps and to undertake future monitoring requirements.

Figure 4-1. Action Summary

No.[a]	Project Description	Lead Agency/Commitment[b]										
		BR	EC	EPA	FDL	GP	KBIC	MI	MN	ON	RC	WI
		LEVEL										
1	Establish voluntary agreements to reduce use, discharge or emissions of the nine designated chemicals		1	1				1	1	1		1
2	Establish voluntary agreements to reduce the use or releases of PCBs			1								
3	Continue discussions with seven pulp and paper mills		1							1		
4	Evaluate economic incentives to promote reductions							2				
5	Provide financial support for pollution prevention projects	1		1				1	1			1
13	Develop purchasing policies to eliminate mercury or PCB equipment	1						1	2			
14	Introduce process chlorine-free paper products						1				1	
18	Develop depot and reverse distribution systems for citizens		1	1				2		2		
19	Encourage dialogue on import of mercury-bearing products and nationwide labeling of mercury products			2				1	2			
20	Establish depots for mercury-containing household products		1							1		
21	Investigate feasibility of redrafting legislation to accommodate product stewardship									2 PM		
22	Promote energy conservation programs	1	2	1				1	1	1		1
23	Home and industry energy audits	1	2					1		1		
24	Encourage municipal energy councils		2						2	1		
25	Establishment of mandatory “line charge” for demand side energy efficiency projects								2			
26	Incorporating energy conservation into new structures				1							
27	Encourage upgrades to energy-efficient thermostats					1						1
28	Re-lamping with fluorescent lamps						1					
32	Initiate or continue permanent household and agricultural hazardous waste collection depots	1	2	1	1		1	1	2	2 PM	1	1
33	Assist in conducting industrial clean sweeps and use economy of scale for collections and shipments of hazardous waste	2						2			1	1
34	Initiate and continue periodic abandoned “white goods” collections	1			1	1	1	2			1	

Figure 4-1. Action Summary

No.[a]	Project Description	Lead Agency/Commitment[b]										
		BR	EC	EPA	FDL	GP	KBIC	MI	MN	ON	RC	WI
		LEVEL										
35	Complete the PCB and mercury Clean Sweep pilot project and recycle PCB-free oil			1								
38	Increase awareness of the risk of pesticides use			1						2 PM		
47	Insist on highest standards and best available technology for new incinerators		2	2								
48	Prevent of remove chlorinated or mercury containing material from incinerator feedstocks		2					1		1		
49	Burn barrel outreach and local ordinances	1		1	1			1	1			1
50	Evaluate adoption of law prohibiting disposal of mercury-bearing waste							1				
51	Municipal source separation programs to divert household hazardous materials		1							1		
55	PCB "mentors" to assist small facilities		1	1				2	2			
56	Formation of PCB cooperatives		1						1	1		
57	Include PCBs in outreach and hazardous waste collections for small businesses	1	2	1				2		1		
58	Destroying PCBs in use or storage	2		1				2	2	1		
59	Training sessions for small PCB owners		1							1		
60	Monitoring and documentation of PCB-bearing equipment until removal		1							2 PM		
61	In-basin destruction capability for low level PCBs		1							1		
62	Testing of transformers and capacitors to identify remaining PCBs			1				2	1			
63	Removal of PCB-bearing equipment in lieu of fines	2		1				1				
64	Testing and removal of PCB-bearing equipment outreach	2							2			
65	Endorsement of PCB reduction goals by power generators			1				2				
66	Formalize the PCB Phasedown Program pilot project			1								
67	Identify federally-owned PCBs			1								
69	Provide training materials for appliance recyclers and auto salvage operators		2					1	1			

Figure 4-1. Action Summary

No.[a]	Project Description	Lead Agency/Commitment[b]										
		BR	EC	EPA	FDL	GP	KBIC	MI	MN	ON	RC	WI
		LEVEL										
71	Training sessions for demolition contractors	2		2				2	1			1
73	Seek out and dispose of mercury and PCBs on school property	1		1				1	1	1		1
75	Develop and distribute information on mercury reduction at schools through the Binational Toxics Strategy			1								
76	Basin-wide coordination of citizen and school monitoring programs	2			1							2
77	Use of a mercury-sniffing dog in schools								2			
78	Green school programs										1	
79	Supplement and develop new curricula aimed at reducing the nine designated chemicals		1									
87	Information on compliance with revisions to Underground Injection Control Regulations			1								
88	Funding for toxic reduction activities and networking	1										1
89	Small business utilization of hazardous waste depots		2							1		
93	Identify facilities using wet scrubbers and investigate control technology								1			
94	Mercury reduction technology for taconite and electric utility industries								2			
95	Conversion from coal burning to alternative sources								2			
96	Experiments to separate mercury-bearing pyrite fraction from coal								1			
100	Making facilities “mercury free” and pollution prevention projects	1	1	1			1	1	1	1		1
101	Partnerships with dental associations	2	1					1	1	1		
103	Voluntary agreements with the health care industry to reduce mercury and dioxin	1	2	1				1		1		1
104	Voluntary agreement with the American Hospital Association			1								
105	Mercury thermometer swap program				1	1						
106	Discontinue sending mercury thermometers home with new mothers and use non-mercury thermometers										1	
107	Apply results of the 1999 City of Toronto pilot to the Thunder Bay area		2							2 PM		
108	Regulatory exemption for mercury wastes reclaimed from dental offices									2 PM		

Figure 4-1. Action Summary

No.[a]	Project Description	Lead Agency/Commitment[b]										
		BR	EC	EPA	FDL	GP	KBIC	MI	MN	ON	RC	WI
		LEVEL										
114	Alternative energy sources	1				2			2	2 PM		
116	Determination on regulation of mercury emissions from electric utilities			1								
117	Funds to support mercury research in a number of priority areas			1								
118	Workshops on reduction of mercury-containing devices at utilities			1								
119	Utilities converting from coal burning to alternative sources								2			
120	Conversion from coal burning to natural gas for utilities; householders develop an energy conservation ethic										2	
125	Remove PCBs in storage at pulp and paper mills		1							1		
126	Clean up of mercury-contaminated sediments in Peninsula Harbour		1							2		
127	Reduce dioxin and furan discharges from pulp bleaching process									1		
128	Assessment of existing wood preservation facilities and voluntary programs		1									
137	Development of a mercury reduction plan at a manufacturing plant			1								
138	Use, generation, and environmental release of critical pollutants at oil refineries											2
141	Expand the Pollution Prevention Demonstration Site Program to include Canadian Federal facilities and First Nations		2									
144	Coordinate critical pollutants reduction strategies with TMDL reductions or limits under Ontario's Certificate of Approval process				1				1	1		
145	Technical and regulatory assistance on how to identify and address Class V wells that may endanger groundwater			1								
146	Priority review to priority Class V wells within source water protection areas			1								
147	Bans on non-essential uses of the nine persistent, bioaccumulative, toxic substances targeted for zero discharge	2						2	2			
148	Require toxic reduction plans in new or reissued NPDES permits	2						1				

Figure 4-1. Action Summary

No.[a]	Project Description	Lead Agency/Commitment[b]										
		BR	EC	EPA	FDL	GP	KBIC	MI	MN	ON	RC	WI
		LEVEL										
149	Include appropriate limits for persistent, bioaccumulative, toxic substance in air emission permits							1	2			
150	Pollution prevention components in enforcement settlements							1				
151	Identify opportunities to reduce storage, use, or release of mercury and PCBs			1				1				
152	Regulations to require monitoring and reporting emissions from industrial and commercial emission sources									1		
156	Applicability of ONRW designation in future reviews of water quality rules								1			
162	Provide sector-specific pollution prevention outreach	1	2	1				1				1
163	Source separation program to divert household hazardous material from landfills and burn barrels						1					
164	Partnerships between the Hearth Products Association for wood stove change-out program			1								
165	Public awareness campaign for community toxic reduction activities				1						1	
166	Recognition program for wastewater treatment plants that implement the Blueprint for Zero Discharge										2	
167	Reduce reliance on petroleum hydrocarbons for energy production and heating at First Nations		2									
168	Support First Nations on contaminated site assessment and remediation		1									
176	Pursue the Great Lakes Binational Toxics Strategy for mercury, PCBs, dioxins, HCB, OCS, and pesticides		1	1				1	2			
178	Require emission limits on pollutants for all operating medical waste incinerators			1								
179	Lowering the nationwide limits on sewage sludge and medical waste incinerators								2			
180	Close the RCRA Subtitle C loop that allows incineration of mercury-bearing hazardous waste								2			
181	Regulations providing cap and trade of mercury emissions											1

Figure 4-1. Action Summary

		Lead Agency/Commitment[b]										
No.[a]	**Project Description**	BR	EC	EPA	FDL	GP	KBIC	MI	MN	ON	RC	WI
		LEVEL										
182	Establish a national ambient air toxics monitoring network											1
183	Participation in the Great Lakes Regional Air Toxics Emissions inventory											2
184	Purse reductions of mercury, dioxin and hexachlorobenzene through source reduction elimination/segregation at medical waste incinerators	1										
187	Lower reporting limits on persistent, bioaccumulative, toxic chemicals under TRI and NPRI and for PCBs under TSCA	1	1	1					2			
188	Nationwide product stewardship and reverse distribution systems								2			
189	Provide incentives to the utility industry to develop mercury control technology								2			
190	Tighten reporting requirements on export shipments of pesticides								2			
191	Permanently retire U.S. government stockpile of mercury and other sources of elemental mercury			1				2	2			
194	Initiate necessary sediment remediation measures at AOCs		1						2	1		2
195	Complete remedies for Torch Lake and St. Louis River			1								

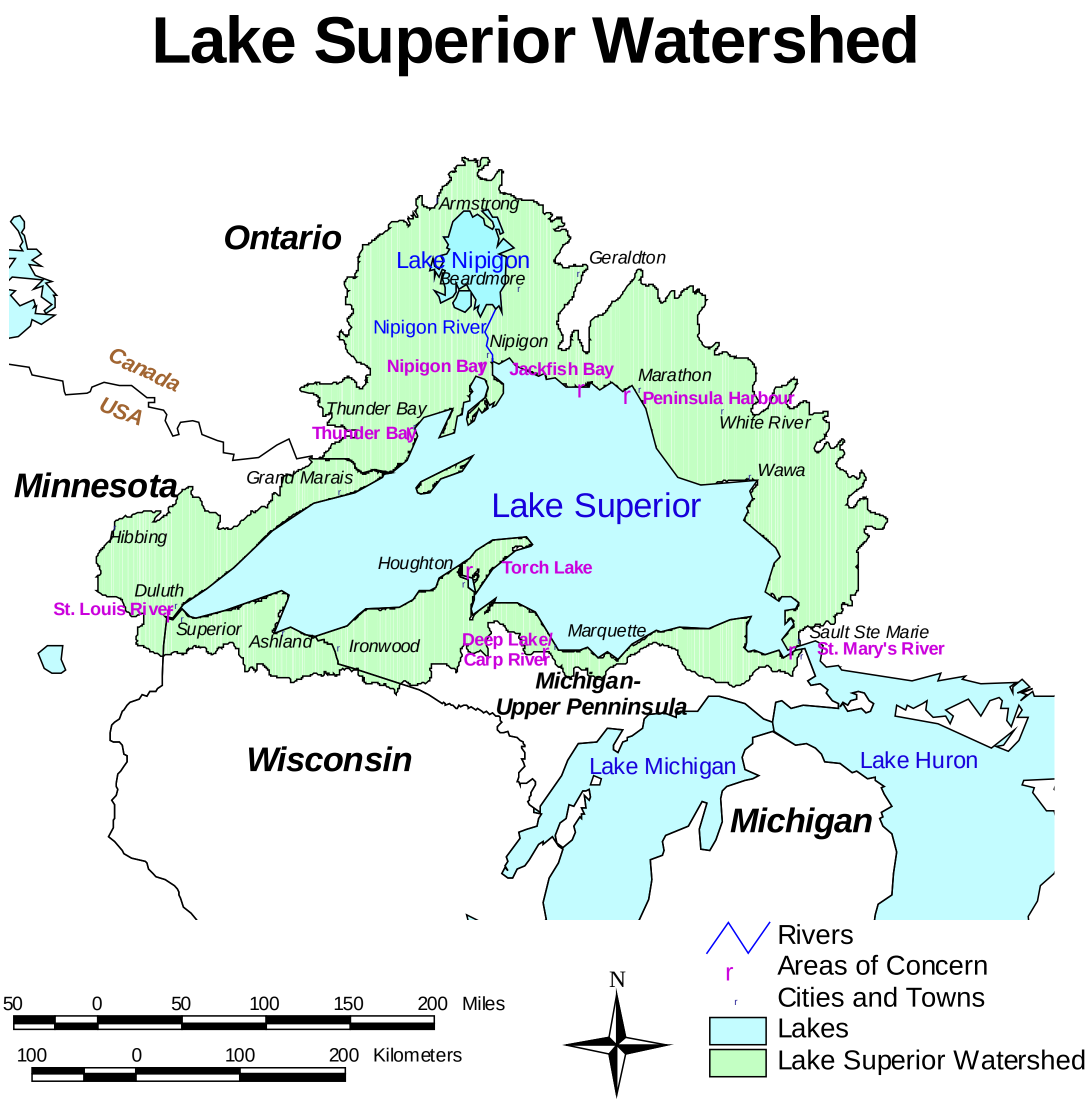
Notes:

a Numbers correspond to number assigned in this chapter of the LaMP.

b Level 1 commitments are actions currently supported or planned to be supported by agencies and member organizations within the next two to three years with funds and/or personnel. In some cases, the initial stages of those activities ranked at this level may already have been completed by some of the agencies or partner organizations such as municipalities. Level 2 commitments are actions that require additional resources or policy decisions in order to be accomplished or supported. In some cases these actions are as important as those in rank (1) to achieve zero discharge.

PM = Policy matter

Figure 4-2. Lake Superior Watershed



4.0 ABOUT THIS CHAPTER

The Lake Superior basin is one of the most unique and fragile ecosystems in North America. Hydrologically, the lake functions as the headwaters of the Great Lakes St. Lawrence basin. The waters are cold and the food chain of the lake is simple. The human populations are sparse and the economy is based on natural resources that require careful conservation.

Annex 2 of the 1987 Canada-U.S. Great Lakes Water Quality Agreement contains a framework for Lakewide Management Plans to restore beneficial uses and reduce the loadings of critical pollutants. In their 1990 biennial report the IJC commissioners called the two governments to establish a Zero Discharge Demonstration Area for Lake Superior. In response government agencies in 1991 established *The Binational Program to Restore and Protect the Lake Superior basin*, also known as the Lake Superior Binational Program (LSBP). Included in this program are a Zero Discharge Demonstration Project, where no point source discharge of any persistent, bioaccumulative, and toxic substance would be permitted, and a broader program that focuses on the non-chemical elements of the Lake Superior ecosystem. While the Lakewide Management Plan (LaMP) process is part of the GLWQA, the LaMP is also serving to carry out the goals and objectives of the Lake Superior Binational Program.

Stages 1 and 2 of the chemical portion of the LaMP, which describe the status of pollutants in the Lake Superior ecosystem and set load reduction targets and schedules for critical pollutants respectively, have been completed. This document, released in 1999 as the draft Stage 3 of the LaMP process, proposed remedial measures for Lake Superior critical pollutants. Based on considerable public and agency review this document was extensively revised and now forms the chemical part of the LaMP 2000.

Section 4.1 succinctly itemizes the quantities of reductions in each country required to meet program milestones established in the stage 2 LaMP for the years 2005 and 2010. This section also provides tabulations of the reductions achieved since our baseline year of 1990. In some cases the 2000 milestones have already been met. The activities needed to achieve the load reduction schedules are identified in Sections 4.2 and 4.3. Specifically, Section 4.2 identifies actions categorized by chemical pollutants while section 4.3 catalogues a larger set of actions arranged by socioeconomic sector. Section 4.4 describes the impairment and status of actions at contaminated sites most of which are within Great Lakes Areas of Concern (see Appendix A for more information on AOCs). Section 4.5 introduces monitoring activities that could be used to track progress toward the goal of zero discharge and zero emissions. Section 4.6 is a short summary of planned program activities.

The implementation activities described in this chapter on critical pollutants are recognized as near-term actions. That is, some of these activities will lead directly to load reductions, while others will prepare the way for more difficult and long-term reductions that are required if we are to demonstrate zero discharge in the basin. The Lake Superior environmental agencies recognize that reduction activities will be needed well into the future. However, it is not possible at this point to identify every action that needs to be taken. As a result, this document describes those activities that the agencies will undertake or encourage others to implement in the next two to three years. The LaMP is intended as a living plan for action that will be updated every two years by the LSBP agencies.

The iterative nature of the LaMP allows agencies to pursue short term load reductions and long term strategies concurrently. We are well aware that the commitment to zero discharge by 2020 will require the imagination and planning of all stakeholders.

In future iterations LaMP documents, additional commitments will be identified, progress will be tracked and additional evaluations of the lake and its critical elements will be presented. Like the Lake Superior ecosystem itself, the LaMP process is evolving and adapting to the needs of the lake and its people.

4.1 PROGRESS TOWARD ZERO DISCHARGE

Section 4.1 discusses the progress made in the Lake Superior basin for the nine virtual elimination pollutants. Section 4.1.1 discusses strategies for reduction and Section 4.1.2 describes load reductions for mercury, PCBs, dioxins, and pesticides.

4.1.1 Strategies for Reduction

The LaMP Stage 2 mapped out a path for zero discharge by establishing load reduction schedules and targets. Table 4-1 provides a summary for the nine virtual elimination pollutants. Stage 3 goes the next step by identifying the reduction strategies and actions needed to achieve the targets. While it is not possible to identify all the strategies considering that the timeline stretches until the year 2020, the following actions are needed in order to meet the next milestones coming up in either 2005 and 2010:

Mercury: in order to meet the 2010 target of an 80 percent reduction, discharges and emissions will need to be reduced from 2,444 kg/yr in 1990 to 489 kg/yr in 2010. The largest contributing sources are mercury from products, mercury emitted from the mining sector and fuel combustion.

PCBs: in order to meet the 2005 target of 60 percent reduction, both countries will need to destroy PCBs in use or in storage. In Canada, an additional 173,427 kg of high level PCBs should be destroyed and low level PCB destruction should be tracked. At present, the US inventory is insufficient to give an accurate estimate. Untested equipment must be tested, owners should begin decommissioning PCBs that are currently in use and the governments should assist the effort to test and decommission. The U.S. testing will lead to an improved inventory so progress towards the 2005 target can be better quantified.

Dioxin/HCB/OCS: While the US and Canada appear to already be ahead of the 80 percent reduction by 2005 target for dioxin/HCB/OCS, there are gaps in the inventory. As more information becomes available on the sources and loads from the basin, estimates for the base line year may change, which will also change our estimate of progress towards the 2005 goal. In the meantime, the remaining largest sources of dioxin within the basin, appear to be burn barrels, wood treatment with pentachlorophenol (PCP) and the disposal of fly ash from the incineration of medical wastes. Reduction strategies that should be applied before 2005 include public education and aggressive identification of burn barrels and investigation of ongoing use of PCP and PCP contaminated sites.

Pesticides: The Stage 2 LaMP schedule is to retrieve and destroy all stockpiles in the basin by 2000. Although large amounts of stored pesticides have been collected from the basin, it is unlikely that all stockpiles have been found or properly destroyed. Beyond 2000, the reduction strategies for pesticides include continued or expanded collection opportunities coupled with public outreach. Numerical targets for pesticides are not possible since the amounts remaining in the environment are not quantifiable.

The remainder of Section 4.1 documents the progress towards zero discharge and zero emission between the baseline year of 1990 and the current year. It also shows the reductions that are needed from different sources in order to achieve the next milestones in 2005 and 2010. Addendum A details the inventories and assumptions used in Section 4.1.

Table 4-1 Summary of Reduction Goals for Lake Superior Virtual Elimination Pollutants

Pollutant	Goal for Lake Superior Environment	Reduction Schedule
Mercury	Virtual Elimination	60 percent reduction by 2000 80 percent reduction by 2010 100 percent reduction (zero discharge/zero emission) by 2020 (applies to in-basin sources) (1990 base line)
PCBs	Virtual Elimination	Destroy accessible/ in-control PCBs 33 percent destruction by 2000 60 percent destruction by 2005 95 percent destruction by 2010 100 percent destruction by 2020 (1990 base line)
Pesticides Aldrin/Dieldrin Chlordane DDT/DDE Toxaphene	Virtual Elimination	Retrieve and destroy all canceled pesticides in the basin by the year 2000
Dioxin [1] HCB OCS	Virtual Elimination	80 percent reduction by 2005 90 percent reduction by 2010 100 percent reduction by 2020 (1990 base line)

1 The Binational Program lists 2,3,7,8-TCDD (dioxin) for the Zero Discharge Demonstration Program. By convention, dioxin is measured and reported as toxic equivalents (TEQ)

4.1.2 Load Reductions

The Lake Superior basin is the focus of the Zero Discharge Demonstration Project, which has set a philosophical goal of zero l discharge and emissions from in-basin sources for nine persistent, bioaccumulative toxic chemicals. The complimentary goal is the virtual elimination of these chemicals form the environment although our understanding of all the inputs and fate is not complete. Because the sources of these chemicals are located throughout the world and deposition from the atmosphere to the basin is significant, the virtual elimination of these nine chemicals from the basin will require that both Lake Superior Binational Program (LSBP) agencies and citizens support and participate in state, provincial, national, and international efforts to reduce the use and emissions of these persistent bioaccumulative toxic chemicals. The Zero discharge demonstration program for Lake Superior is viewed as a challenge to society to develop pollution prevention innovations that go beyond “end-of pipe” pollution control solutions. It is a fundamental shift from reliance on control to prevention. This involves examination of how the target chemicals are used and formed in products and processes. The zero discharge demonstration program represents a societal goal for the Lake Superior basin. It is not a regulatory program.

The agencies of the LSBP have developed a set of principles to guide the load reduction schedules and activities to meet them. These “guiding principles” were developed as a result of public comment received during development of the Stage 2 LaMP and appear in that document as well (LSBP 1999).

- The parties of the Binational Program commit to move beyond the *status quo* (i.e., activities that go beyond regulatory compliance will be encouraged). Progress is more than meeting current regulations. Progress in some sectors will be difficult to quantify. Qualitative descriptions of progress will also be needed.
- The reduction schedules are planning targets for the entire basin and are not schedules for specific facilities, sectors, jurisdictions or sources.
- The endpoint of the load reduction schedules is zero discharge. The approach is staged reductions.
- The reductions will be achieved through maintenance of regulatory standards and through source reduction, new technologies, material substitution, pollution prevention, recycling, education and awareness programs, and development of new waste disposal and pollutant destruction capabilities. The pollution prevention approach is the preferred strategy.
- The LaMP addresses all in-basin sources. Other mechanisms will deal with out-of-basin sources.
- In going beyond regulatory control requirements, the solutions cannot create social or economic situations that regionally disadvantage the residents of the Lake Superior basin. Actions taken to fulfill the schedules must be consistent with a sustainable economy.
- The reduction of pollutants will not be based on removal from the Lake Superior basin to other basins (transference). In-basin solutions are preferred.

- Approaches are to be characterized by flexible implementation.
- While voluntary reductions are encouraged, incentives must also be developed to support the implementation of these approaches. Actions do not necessarily need to be legally-driven.
- Delivery of the Lake Superior Binational Program goes beyond the agencies directly involved. Other agencies and other parties have a role.
- The Lake Superior Binational Forum and other stakeholders are to be consulted on a continuous basis.
- The targets described in the LaMP for Critical Pollutants support the other theme areas of the Lake Superior Binational Program (human health, sustainability, habitat, aquatic and terrestrial communities, and communications).

In the last decade, it is not uncommon for pollutant reductions to be discussed with the broader context of social, economic and ecological sustainability. The process is much more complex and not limited to eliminating a specific chemical in the environment or rehabilitating a single stream. Perhaps the greatest challenge for achieving sustainability rests in its lack of a clear, agreeable definition. The true measure of a sustainable society is on the scale of generations rather than years. At the very least, we must conserve existing resources in the basin so that our descendants can enjoy the same quality of life as the present generation, if not a qualitatively better standard of living. Any plan for developing sustainability must be flexible and responsive to changes. The reductions cited below track one decade of progress.

Since the 1990 baseline year, releases of the nine designated chemicals have declined in the Lake Superior basin. The reductions have occurred for the following reasons:

1. <u>Reduction efforts by facilities in the basin:</u> For example, the Western Lake Superior Sanitary District pledged to become a zero discharge facility and succeeded in significantly reducing mercury in treated wastewater and sludge through aggressive source reduction and pollution prevention measures.
2. <u>New competitive technologies have replaced old technologies:</u> For example, most of the pulp and paper mills in the basin that used elemental chlorine before 1990 are now using 100 percent chlorine dioxide.
3. <u>Facility closures:</u> For example, due to market conditions and aging facilities, a copper smelter and paper mill in the U.S., and a zinc mine and iron smelter in Canada were closed.
4. <u>National and regional regulations</u>: For example, Canadian dioxin effluent limitations had a role in causing pulp and paper mills in the Lake Superior basin to switch to chlorine dioxide bleaching; in the U.S., mercury battery legislation passed in Minnesota was the impetus for a nationwide shift to mercury-free battery manufacturing; in the U.S., air toxics regulations have precluded continued operation of small waste incinerators, removing that major source of dioxin emissions.

This section describes load reduction estimates for 1990 to 1999. More details on the 1990 base line estimates can be found in Stage 2. The 1999 estimates are based in part on new Canadian estimates (Brigham 1999). The US and Canadian assumptions behind the 1999 numbers are explained in Addendum A. Data will be available in the coming year to better assess whether the year 2000 milestones have been met.

4.1.2.1 Mercury

Significant reductions in mercury use and emissions in the Lake Superior basin have occurred for two principal reasons. First, production at the White Pine Mine copper smelter in Michigan and Algoma Ore Division iron sintering facility in Ontario have ceased, resulting in a significant reduction in mercury air emissions. Second, mercury in products, such as batteries, paints, and fungicides, has been reduced, resulting in over an 80 percent decline in mercury content in commercial products. In contrast, mercury emissions continue at relatively high levels from mining operations and fuel combustion.

Mercury Reduction Goals

The reduction goals for mercury include the following: (1990 baseline)

- 60 percent reduction by 2000
- 80 percent reduction by 2010
- 100 percent reduction by 2020

The 1999 estimate of 819 kg/yr of on-going mercury releases is a 66 percent reduction from the 1990 estimate of 2,444 kg/yr (Table 4-2). An additional 330 kg/year (Table 4-2) must be reduced in order to meet 489 kg/yr, the 2010 80 percent reduction milestone. This estimate meets the year 2000 LaMP milestone of 60 percent reduction, however, other factors such as taconite production will have an effect on the final year 2000 release estimates.

Sources of Mercury

The mercury inventory, listed in Table 4-2 below, includes a variety of releases to air, water, and soil. The reduction estimates are expressed as ongoing releases, for example, mercury emissions resulting from product processes, and potential releases, such as mercury emissions resulting from product disposal. The estimated ongoing releases shown in Table 4-2 include air and water mercury releases in the Lake Superior basin. Estimated potential releases listed in Table 4-3 represent the mercury disposed in landfills or applied to land. Addendum A contains references and a detailed summary of estimated mercury release and disposal for U.S. and Canadian portions of the Lake Superior basin for 1990 and 1999.

Overall, mercury releases have declined from most sources in the basin The increase in the estimate of mercury releases from total sludge in Table 4-1 is because of the development of a new process technology at the Western Lake Superior Sanitary District (WLSSD) in Minnesota scheduled for completion in 2001. During the interim, half of the sludge generated is being applied to land while the other half is being incinerated at WLSSD. Once the new process is in place, sludge will no longer be incinerated and the overall volume of sludge generated will be reduced. In addition, the estimated emissions from small incinerators were added to the estimate of mercury in sludge because most small incinerators in the basin have closed since 1990.

The potential release estimates for mercury-containing products such as thermometers, thermostats, and dental products, may be lower than indicated in Table 4-3 due to state and community mercury-reduction activities in the basin that may be difficult to quantify at the basin level. For example, the Thermostat Recycling Corporation collected a total of about 9,660 mercury-switch thermostats in Michigan, Minnesota, and Wisconsin in 1998, diverting about 77 pounds of mercury from the municipal waste stream in those states (Erdheim 1999). The states and province have also developed mercury pollution prevention and reduction strategy programs, such as community clean sweeps and developing outreach materials.

Mercury in products which are disposed in landfills may be eventually released to the environment through volatilization. At the 5th International Conference on Mercury as a Global Pollutant in 1999, two researchers independently estimated that an average of 15 percent of the mercury contained in products is released during the disposal process (Andrews and Swain 1999, and Kindbom and Munthe 1999). Therefore, 15 percent of the potential release of mercury in Table 4-3 is re-emitted and is added to the ongoing release category (shown in Table 4-2).

Taconite production continues to be a substantial source of mercury emissions in the U.S. basin. Fuel combustion (for example, energy production) is a major release source in both countries. The mining and fuel combustion sectors have a combined estimated release of 654 kg/yr. These two sectors will need the most effort to achieve mercury reduction in the next 10 years. At present, there are no mercury emission limits and cost-effective technologies are still under development to limit emissions from taconite processing facilities and coal-fired utilities. In fact, the taconite industry is projected to grow in the next 10 years as is per capita consumption of electricity.

Table 4-2 Ongoing Release: Mercury to Air and Water from Sources in the Lake Superior Basin, 1990 and 1999 (kg/year)

Source	US 1990[a]	Canada 1990[a]	Total 1990[a]	US 1999[b]	Canada 1999[b]	Total Remaining 1999	Percent Reduction
Industrial	11	24	35	11	20	31	11 percent
Mining	912	604	1516	385	0.4	385.4	75 percent
Fuel Combustion	193	125	318	193	76	269	15 percent
Incineration	95	2	97	14	1	15	84 percent
Products[c]	150	44	194	1	14	15	92 percent
Municipal	61	11	72	40	11[d]	51	29 percent
Re-emission (15 percent of Table 4-2 total)	146	65	212	34	19	53	75 percent
Total	1568	875	2444	678	141	819	66 percent

[a] Stage 2 LaMP mercury release estimates (LSBP 1999).

[b] See Addendum A for assumptions and references for 1999 ongoing mercury release estimates.

[c] Data in common for the U.S. and Canada are electric lighting, paint and fungicides.

[d] This estimate does not include reductions from household hazardous waste collections or improved handling of waste amalgam in Ontario.

Table 4-3 Potential Release: Mercury to Landfills and Soils from Sources in the Lake Superior Basin, 1990 and 1999 (kg/year)

Source	US 1990	Canada 1990	Total 1990	US 1999	Canada 1999	Total Remaining 1999	Percent Reduction
Dry Cell Batteries	851	300	1151	85	15	100	91 percent
Other Products	117	100	217	74	84	158	27 percent
Medical/Dental	6	22[a]	28	6	22[a]	28	0 percent
Ash[b]		10	10		5	5	50 percent
Sludge[c]	4	2	6	61	2	63	+1,050 percent
Total	972	434	1412	226	128	354	75 percent

[a] This estimate is partially doublecounted in other categories and does not include reductions due to improved handling of waste amalgam.

[b] An estimate for U.S. potential release from ash is not available.

[c] Sludge is applied to land and landfilled. This estimate includes the estimate for materials previously being incinerated in small incinerators (48 kg/yr), the sludge from the Duluth WLSSD that is applied to land, and 10 percent of the mercury in total commercial/ municipal effluent. This does not include sludge burned at WLSSD, which is included under Incineration in Table 4-2.

A substantial portion of mercury also enters the basin as a component of commercial products. Voluntary bans on mercury-containing paints and fungicides in the early 1990s and reduced mercury content in batteries has resulted in over an 80 percent reduction of mercury from commercial products. In 1992 and 1993, the use of mercury in round cell, alkaline, and zinc carbon batteries was discontinued (NEMA 1999), resulting in a 90 percent reduction in mercury from batteries. The mercury content of products is expected to further decline, which will decrease the 354 kg/year contribution from potential releases (see Table 4-3) and the 112 kg/year from ongoing releases from municipal, incineration, products and industrial sources (see Table 4-2). The estimated 354 kg/year to landfills and soils is a source for an additional 53 kilograms of re-emitted mercury, bringing the total ongoing releases from all sources, except mining and fuel combustion, to an estimated 165 kg in 1999. In addition, the populations of the U.S. counties in the basin are generally projected to decrease, which should cause a decrease in consumption of mercury-bearing products.

Strategies for Reduction of Mercury

The mercury release target for 2010 is 489 kg/yr. To meet this, a further reduction of 330 kg/yr is required from current emission rates. Purposeful use of mercury in processes and products is the source of much of the mercury released from incineration and municipal sources. For example, if all ongoing releases from municipal, incineration, products, and industrial sources were eliminated (165 kg/yr), the total amount of reductions needed from the mining and energy production sectors would be about 165 kg/yr to meet the 80 percent reduction goal for the year 2010. Sections 3.1.4 and 3.1.5 discuss mercury reduction strategies through purchasing policies and product stewardship, which are some important strategies to address purposeful use of mercury.

However, it is unlikely that all municipal, incineration, products, and other industrial sources will be eliminated by the year 2010. An alternative example assumes that if half of the mercury from these sources were to be eliminated, the mining and energy production sectors would need to reduce mercury releases by about 248 kg/year by the year 2010. Sections 3.1.6 and 3.2.6 outline some reduction strategies that apply to energy conservation and production. Section 3.2.4 outlines reduction strategies specific to the mining sector. For mercury reduction in the mining sector, voluntary agreements and mercury emission control technologies offer the greatest potential for reductions. Currently there are four major utilities and seven taconite mines in the basin to share this responsibility.

Summarized goals for mercury reduction in 2010:

- The overall goal is an additional reduction of 330 kg/year to meet the 80 percent reduction milestone of 489 kg/yr.

This goal may be achieved by different combinations of reduction strategies. For example:

- Reduce the mercury released from municipal, incineration, products, and industrial sources by half between 2000 and 2010, resulting in a reduction of approximately 82 kg/year. For the most part, these sources ultimately originate with the purposeful use of mercury in products or processes. Important reductions from these sources have taken place between 1990 and 1999.

- Reduce mercury from the mining and energy production sectors by 248 kg/year, which is less than half of the 1999 estimated emissions. Significant reductions in mercury from these sectors have not taken place between 1990 and 1999 with the exception of facility closures.

4.1.2.2 PCBs

The LaMP reduction goals call for 100 percent destruction of PCBs in the Lake Superior basin by the year 2020. The main concern with PCB reductions within the Lake Superior basin is not their ongoing release, since PCBs are rarely found in permitted discharges and emissions. The PCB reduction goals for Lake Superior are aimed at preventing future release by destruction of PCBs in use and storage. The goals also address clean up and destruction of PCB contaminated soils and sediment, where accessible. Regionally, PCB volatilization from past releases and eventual atmospheric deposition is a significant pathway for PCBs to Lake Superior.

PCB Reduction Goals

The reduction goals for accessible PCBs include the following (1990 baseline)

- 33 percent destruction by 2000
- 60 percent destruction by 2005
- 95 percent destruction by 2010
- 100 percent destruction by 2020

Currently, in the U.S. portion of the Lake Superior basin, approximately 345 PCB transformers and 3,700 PCB capacitors remain in use (see Addendum A), primarily owned by large and small utilities and industries. These estimates are based on extrapolation from a Minnesota survey (Addendum A) No actual inventory exists for PCBs on the U.S. side of the Lake Superior basin. Though there are no PCB disposal facilities in the U.S. portion of the Lake Superior basin, the opening of a licensed facility in Michigan should result in increased disposal activity.

In the Canadian Lake Superior basin, approximately 157,977 liters of high-level PCB-contaminated liquid remained in use in 1997; 157,179 liters of PCB-contaminated liquids and 205,807 kg PCB-contaminated solids remained in storage. Between 1990 and 1997, 276,493 kg PCB-contaminated solids were destroyed and 138,657 liters of PCB-contaminated liquids were destroyed (Brigham 1999). These estimates indicate that the United States and Canada are making progress toward attaining the goal of 60 percent decommissioning and destruction of PCB-contaminated equipment by 2005.

Sources of PCBs

Although PCB production was banned over 20 years ago, PCBs are still found in old commercial, industrial, and electrical equipment. PCBs are also produced incidentally through as many as 200 chemical processes. However, it is estimated that 95 percent of the PCB load to the Lake Superior ecosystem is via air deposition (U.S. EPA 1998a). Volatilization of PCBs from soils and sediments is also a significant contributor to PCBs in the water column and the biota. In the Lake Superior basin, the majority of continuing releases are thought to be from electrical equipment oil spills, while small amounts could be released from fuel combustion, waste oil combustion, biomedical waste incineration, and wastewater treatment plants.

PCBs are also found in harbor sediments in some Lake Superior Areas of Concern. Total amounts have not been determined. The amount of PCBs in contaminated soil and landfills is also unknown.

Canadian facilities have made substantial progress in destroying PCB-contaminated equipment and materials throughout the basin. While the major utilities and some industrial facilities in the U.S. portion of the Lake Superior basin have made substantial progress in replacing and disposing of their PCB-contaminated transformers and capacitors, small utilities and other industrial facilities must begin to more aggressively identify and decommission their PCB-contaminated equipment.

The total PCB inventory for the entire Lake Superior basin is difficult to assess because of the differences between U.S. and Canadian reporting requirements. The U.S. has calculated the weight of pure PCBs in previous estimates. Canada requires facilities to report PCBs by weight of contaminated equipment and materials. Recent changes to the U.S. Toxic Substances Control Act (TSCA) require that owners of transformers containing greater than 500 ppm PCBs must register their equipment with the U.S. EPA. The two nations also have different definitions of "high level" PCBs (e.g., in the U.S. a concentration greater than 500 ppm is considering high and in Canada, a concentration greater than 10,000 ppm is reported as high).

The individual U.S. states are also beginning to compile more detailed inventories of PCB use. For example, the Minnesota Pollution Control Agency (MPCA) has recently completed a survey of PCB containing equipment used by northeastern Minnesota industries, utilities, schools, and municipalities. Michigan similarly has an ongoing Critical Materials Register that requires facilities to track PCBs. These new data and initiatives will improve the U.S. portion of the Lake Superior PCB inventory.

Current Use of PCBs

Table 4-3 lists the quantities of PCBs estimated to be in use in both the U.S. and Canadian portions of the basin in the baseline year of 1990 and in 1999. The current U.S. data are limited. As a result, several assumptions were made to estimate the amount of PCBs in use in the basin. Specifically, data from MPCA’s PCB inventory survey was analyzed and applied, on a per-capita basis, to the U.S. portion of the Lake Superior basin (see Addendum 4-A).

Table 4-4 Estimated PCB Use in the U.S. and Canada [kg]

Source	United States		Canada	
	1990[a]	1999[b]	1990[c]	1997[d]
Industrial	(637,346)	(7,369)	194,830	
Utilities	(26,618)		11,300	
Municipal			14,815	
Commercial			32,700	
Total	(663,964)	(7,369)	253,645	181,673

[a] Pure PCBs (LSBP 1999).
[b] Estimates based on MPCA's PCB Inventory Survey, 1999, extrapolated to Michigan and Wisconsin using population-based projections (see Addendum A) (Beadey 1999). This estimate method is not directly comparable to the 1990 method.
[c] LSBP 1999
[d] Brigham 1999. Data cannot be accurately desegregated for each sector.

While the estimate of PCBs in use on the U.S. side of the basin appears to show a large decrease, the base line year of 1990 and the 1999 estimate are based on methods different enough that accurate comparison is not possible. It is highly likely that the amount of PCBs in use on the U.S side of the basin in 1999 is significantly higher than reported. The Minnesota survey that the numbers are based on was not returned by every recipient and the equipment may have a greater volume or higher concentrations of PCBs than was assumed in Addendum A. Also, over half of the electrical equipment identified in the Minnesota survey has not been tested and some of this equipment may contain PCBs. Despite the lack of information on overall U.S. reductions, individual facilities in the basin are achieving reductions. For example, 173,952 kg of PCBs are being decommissioned as part of the closure of the Copper Range mine (Tetra Tech, Inc. 1996). Taconite mines have also decommissioned PCB-bearing equipment and so have the major U.S. electric utilities in the basin.

In Canada, seven facilities in the basin reported a total of 157,977 liters (181,673 kg) of high level PCB liquid in use in 1997 (Brigham 1999). Compared to the base line of 253, 645 kg in 1990, a 28 percent reduction in use has occurred on the Canadian side of the basin.

Table 4-5 shows the amount of high level PCBs destroyed in Canada between 1990 and 1997. Liquid PCBs includes the PCBs found in transformers and capacitors. Solid PCBs includes the PCBs in equipment such as ballasts and contaminated soils. High level PCB liquids and solid wastes have been reduced by 24 percent. Percentage reduction for the other categories cannot be calculated with any confidence given the changes that appear in the baseline as new data are reported. See Addendum A.2.2 for details of PCB use, storage, and destruction in Canada.

Table 4-5 Estimated High Level PCB Destruction in Canada (kg).[a]

Type of Waste	1990	Amount Destroyed
High Level Liquid (storage)	85,112	40,498
High Level Solid (storage)	146,563	77,267
Total (high level storage only)	231,675	117,765
High Level PCBs (use)	253,645	-
Total High Level (in use and storage)	485,320	117,765

[a] After Brigham 1999

In the Canadian Lake Superior basin, approximately 157,977 liters (181,674 kg) of high-level PCB-contaminated liquid remained in use in 1997; 128,001 liters (147,201 kg) of high level PCB-contaminated liquids and 69,296 kg of high level PCB-contaminated solids remained in storage. Between 1990-1997, 117,765 kg of high level PCB-contaminated solids and liquids were destroyed (Brigham 1999). In order to meet the targets of 33 percent reduction by 2000 and 60 percent by 2005, an additional 42,391 kg and 131,036 kg, respectively, of high level PCBs should be destroyed.

Strategies for Reduction of PCBs

Because of the inadequacy of the U.S. PCB data base in the Lake Superior basin, it is not possible to describe a numeric goal for the mass of PCBs that should be destroyed to meet the reduction milestones. However, this Stage 3 LaMP identifies a variety of strategies that would both improve the data base and bring about reductions. It is crucial that 1) untested equipment be tested, 2) owners of PCB-bearing equipment decommission that equipment and 3) governments assist their efforts to test and decommission. Section 3.2.11 lists PCB strategies that cover these areas. Section 4.2.1.2 identifies the PCB strategies that the agencies propose to emphasize in the next two to three years.

In order to meet the 2000 and 2005 PCB reduction goals, Canada will need to destroy a total of 42,391 kg and 131,036 kg, respectively, high level PCBs out of the original 485,320 kg in-use or in-storage in 1990. In addition, reduction estimates for low level PCBs should be improved. Sections 4.2 and 4.3 outline possible alternative reduction strategies that apply to PCB-contaminated equipment reductions in all sectors.

4.1.2.3 Pesticides

Pesticide Reduction Goals

Although the targeted pesticides continue to be collected in Minnesota, Wisconsin, Michigan, and Ontario, environmental concentrations have shown general decline in most media over the years (Pesticides Workgroup 1999). Based upon recent water concentration measurements, the quantities of these pesticides remaining in the water column of all five Great Lakes totals about 22,000 kg which is the equivalent of about 1 kg per cubic kilometer of Great Lakes water. Although concentrations of these pesticides have declined in the Great Lakes basin, current contamination levels remain a concern as reflected by water concentrations that exceed U.S. national water quality standards, sediment concentrations the exceed sediment guidelines, and fish consumption advisories based on unacceptable levels of these pesticides in sport and commercial fish (Pesticides Workgroup 1999).

The Lake Superior Binational Program goal is to retrieve and destroy all remaining stockpiles of the canceled pesticides including DDT, DDE, aldrin/dieldrin, and toxaphene, as well as dicofol (also known as Kelthane), hexachlorobenzene, mercury pesticides, hexachlorobenzene pesticides, and 2,4,5-T (Silvex) and other pesticides contaminated by dioxin or hexachlorobenzene in the basin by the year 2000.

Sources of Pesticides

DDT reached peak annual usage of some 80 to 85 million kg in the U.S. in 1962; toxaphene use peaked in 1972 to 1975 at close to 30 million kg per year; chlordane at 12 million kg in 1971; and aldrin plus dieldrin at 9 million kg in 1966. All of these chemicals were used as pesticides. All of these pesticides were canceled (production is legal, sale and distribution is illegal in the U.S.) by the 1980s for domestic use in the United States and by the 1990s for domestic use in Canada. All but chlordane have not been in production in the United States for many years. One U.S. manufacturer of chlordane, Velsicol Corporation, ceased production for export of chlordane and heptachlor in 1997 (U.S. EPA and Environment Canada 1998b).

Targeted pesticides have been detected in harbor sediments in the Duluth-Superior harbor (Schubauer, Beregan, and Crane 1997, Crane et al. 1997) Time trend atmospheric data from the Integrated Atmospheric Deposition Network (IADN) network for dieldrin, DDT and DDE, and three principal components of commercial chlordane project a decline in atmospheric concentrations to the detection limit (0.1 pg/cu meter) from about 2010 for DDT to about 2060 for DDE with dieldrin and chlordane declining between those years (U.S. EPA and Environment Canada 1998b).

Strategies for Reduction of Pesticides

Although U.S. and Canada domestic production has ceased and uses have been canceled, these pesticides continue to have an environmental presence. In addition, the level of toxaphene in Lake Superior has not shown a general decline over the years like the other pesticides. Collection programs in the Lake Superior basin continue to net these pesticides. Lake Superior strategies for pesticides include continued or expanded collection opportunities coupled with concerted public outreach. Sections 4.3.18, 4.4, and 4.5 discuss the strategies for reduction, contaminated sites and monitoring, respectively.

Out-of -basin strategies addressing pesticides would include support by the Great Lakes states and Canada for international efforts such as the Regional Treaty on Persistent Organic Pollutants, the UNEP Global Treaty on Persistent Organic Pollutants, the Commission for Environmental Cooperation Tri-lateral North American Regional Action Plans, and the NAFTA Technical Working Group on Pesticides to implement phased reduction and eventual elimination of the targeted pesticides in other countries.

The LaMP reduction goal for pesticides is to retrieve and destroy all stockpiles by 2000. The pesticides being targeted are chlordane, DDT, DDE, dicofol (also known as Kelthane), aldrin/dieldrin, hexachlorobenzene, mercury pesticides, toxaphene, Silvex, and other pesticides contaminated by dioxin or hexachlorobenzene. Collection of these pesticides is likely to have side benefits as other pesticides, including two other critical chemicals that are pesticides (hexachlorocyclohexane and heptachlor), are collected at the same time.

Minnesota, Wisconsin, Michigan and Ontario have collected significant amounts of these substances through collection programs in the Lake Superior basin. Unfortunately, the data from these collections are inconsistent, and not always reported by specific pesticide. Stores of these substances apparently still remain in the Lake Superior basin, and as a result, it is not possible to determine that all the stockpiled pesticides will be accounted for by 2000. For example, pesticides may be held by farmers or become orphaned when farm property is sold. Collections should continue in to the future.

Table 4-6 shows that aldrin, chlordane, and DDT have been collected in large amounts in the Lake Superior states from 1990 to 1998. More than 50 percent of the total pounds of pesticides collected was DDT (U.S. EPA and Environment Canada 1998b). The amount of canceled pesticides collected has begun to decline with the exception of DDT (U.S. EPA 1999).

In the early 1980s, Canadian pesticide collections were administered through two clean sweep programs. The last Ontario Ministry of Environment and Energy (OMEE) agricultural waste collection program was conducted in 1991 to 1992. Pesticides have been collected as household hazardous wastes at regional/municipal household hazardous waste depots in Thunder Bay. These depots will continue to collect these substances.

Table 4-6 Clean Sweep Collections Of Pesticides In The Lake Superior States (U.S. Programs)

State	Dates of Collection	Substances Collected - pounds					
		Aldrin/ Dieldrin	Chlordane	DDT	Silvex	Toxaphene	Total Pesticide
Michigan[a]	1995	147	25	193	Not estimated	0	365
Minnesota[b]	1992 – 1998	74	535	4,959	6,000	83	11,651
Wisconsin[c]	1996-1998	0	36	97	28	480	641

a Compiled by Michigan Department of Agriculture. The Lake Superior counties collect about 9 percent of the total substances collected in the state. The substances collected in the Michigan Lake Superior counties were calculated as 9 percent of the total for each substance collected.

b Compiled by Minnesota Department of Agriculture Waste Pesticide Collection Program. Data include all Lake Superior counties' waste pesticide collections.

c Compiled by Wisconsin Department of Agriculture, Trade, and Consumer Protection for 1996. Compiled from collection event summaries from the Northwest Regional Planning Commission for 1997 and 1998.

4.1.2.4 Dioxin, HCB, and OCS

In 1990, most of the dioxin estimated to be released to the atmosphere (370-2,400 g TEQ/year) was produced by small incinerators used at apartment buildings, nursing homes, schools, grocery stores and other small sources in the U.S. Since the 1990 base line estimates were completed, virtually all of these small, inefficient incinerators have been phased out, resulting in a very large reduction in dioxin air emissions. In addition, a significant reduction of about 22 g TEQ dioxin/year resulted from the closure of the Algoma iron sintering plant in Wawa, Ontario and the White Pine Mine smelter in Northern Michigan. Closure of all medical waste incinerators in the U.S. portion of the basin and all but three of the medical waste incinerators in the Canadian portion since 1990 has also resulted in a significant reduction in dioxin emissions in the basin.

For hexachlorobenzene (HCB) and octachlorostyrene (OCS), data are too sketchy to confidently predict the change in releases from sources in the Lake Superior basin since 1990. What little data are available suggest that some of the major sources of dioxin, such as incineration, are also sources of HCB and OCS. Until more and better monitoring data and emission factors are available, dioxin trends will substitute for HCB and OCS trends.

Dioxin, HCB, and OCS Reduction Goals

The goal for the virtual elimination of all dioxin, HCB, and OCS sources within the Lake Superior basin includes the following reduction schedule: (1990 baseline)

- Year 2005:80 percent reduction
- Year 2015:90 percent reduction
- Year 2020:100 percent reduction

The dioxin emission estimates reported in this section indicate that the U.S. and Canada have made significant progress in achieving the 2005 and 2015 goals. As of 1999, dioxin air emissions have declined by 75 to 95 percent, depending on the level of the 1990 baseline estimate. Although direct measurements of HCB and OCS sources are not available, control of dioxin emissions sources is likely to bring HCB and OCS under a similar level of control

Sources of Dioxin, HCB, and OCS

The term "dioxin" represents a class of halogenated aromatic hydrocarbon compounds including polychlorinated dibenzodioxins and dibenzofurans. (Tetra Tech Inc. 1996). There are a total of 210 possible congeners of dioxin, depending on the location and substitution of chlorine in the molecule . Those congeners with chlorine substitution in the 2,3,7, and 8 positions on the molecule are generally thought to be responsible for the greatest degree of toxicity associated with dioxin (U.S. EPA 1998b).

In humans, 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) has been shown to cause chloracne and liver damage. Based upon animal studies, dioxin is also a suspected carcinogen and is thought to be toxic to the immune system and may have detrimental reproductive and developmental effects (U.S. EPA 1995). Because of the high degree of toxicity associated with the 2,3,7,8-TCDD congener, the relative toxicity of other dioxin and furan congeners are assessed in terms of a toxicity equivalency factor (TEF), with 2,3,7,8-TCDD having a TEF value of 1.0. Throughout this document, concentrations of dioxins and furans are presented as a toxic equivalence quotient (TEQ). TEQs are determined by summing the products obtained from multiplying concentrations in grams (g) of individual dioxin-like compounds produced by a source by the corresponding TEF value for each compound (U.S. EPA 1996).

Unlike mercury and PCBs, there are no deliberate uses for dioxin. It occurs purely as a by-product in processes such as combustion and chlorination. In the context of the Lake Superior load reduction schedules, the "dioxin" that is targeted is 2,3,7,8-tetrachloro-dibenzo-p-dioxin because of the high degree of toxicity associated with that specific compound. Furthermore, most research completed to date has focused primarily on identifying sources of the 2,3,7,8-TCDD congener, rather than other forms of dioxins and furans. Nonetheless, to ensure that all potential dioxin congeners are addressed under the LaMP, and because many data are reported as TEQ, the parameter that is being tracked under the load reduction schedule is the TEQ.

In 1990, most of the dioxin produced in the Lake Superior basin was released to the atmosphere (about 400-2,430 g TEQ/year) (see Table 4-7). Roughly 128 g TEQ/year was disposed in soils and landfills, 46 g TEQ were in PCB equipment, 31 g TEQ were estimated to be in contaminated sediment, and only 1.6 g TEQ/year were released into water. Most of the dioxin released to the atmosphere (370-2,400 g TEQ/year) was produced by small incinerators used at apartment buildings, nursing homes, schools, grocery stores and other small sources.
Since the 1990 base line estimates were completed, virtually all of these small, inefficient incinerators have been phased out, resulting in a very large reduction in dioxin air emissions. In addition, a significant reduction of about 22 g TEQ dioxin/year resulted from the closure of the Algoma Ore Division iron sintering plant in Wawa, Ontario and the White Pine Mine smelter in Northern Michigan. Closure of all medical waste incinerators in the U.S. portion of the basin and all but three of the medical waste incinerators in the Canadian portion since 1990 has also resulted in a significant reduction in dioxin emissions within the Lake Superior basin. A summary of Lake Superior basin dioxin emissions from 1990 through 1999 is presented in the table below.

Table 4-7 Summary of Lake Superior basin Dioxin Discharge and Emission Estimates 1990 to 1999

	U.S.[a]		Canada[a]		Total	
Source	1990	1999	1990	1999	1990	1999
Industrial	1.5×10^{-7} - 0.7	0 - 0.3	23.88	2.08		
Fuel Combustion	3.43	0.93	1.04	1.04		
Incineration	369 - 2,408	90.2	0.13	0.07		
Municipal/ Residential	N/A	N/A	0.05	0.05		
Commercial Products	N/A	N/A	0.27	0.27		
TOTAL	374 - 2,413	91.1 – 91.4	25.4	3.5	399.4 – 2438.4	94.6 – 94.9

[a] Canada 1999 figures in g TCDD/yr; U.S. figures in g TEQ-TCDD/yr.
N/A estimates not available.

Although many dioxin sources are now under control in the basin, “backyard burning” by U.S. households and small businesses continues. It is believed that “rural burning” also occurs in Canada. No firm estimate can be made yet for the release of dioxin TEQs from these burn barrels, but preliminary calculations indicate that household waste burned in burn barrels can be a significant source of dioxin compounds. An initial estimate of 6.7 g TEQ/yr from household waste combustion in the U.S. portion of the basin is described in Addendum A.3.1 and is included under Incineration in Table 4-7.

Since the burn barrel estimates are incomplete and the range of the dioxin emitted from small incinerators is so wide, an estimate of progress made towards zero discharge is problematic. However, setting aside the unknown burn barrel contribution yields an approximately 75 to 95 percent reduction in dioxin emissions resulting from the closure of medical waste and other small incinerators and the White Pine and Algoma facilities. The assumptions built into these estimates are explained in Addendum 4-A.

Strategies for Reduction of Dioxin, HCB, and OCS

The significant, remaining sources of dioxin emissions in the basin include small industrial and other waste incinerators, backyard burning of household waste in burn barrels, and possibly the use of pentachlorophenol wood preservative. Because most large emission sources are now under control, the focus must now be placed on small, disperse sources. As a result, the control strategies applicable to these sources should include public education and outreach coupled with aggressive identification of these sources. Strategies should also include investigation of ongoing pentachlorophenol use and, in the long term, clean up of contaminated sites.

4.2 ACTIONS FOR THE NEXT 2 TO 3 YEARS BY CHEMICAL

Section 4.1 updated the pollutant reductions that have occurred since the baseline year of 1990 and made estimates of the reductions required to meet the next targets for each chemical. Sections 4.3 and 4.4 will discuss pollution prevention and reduction strategies utilizing multiple sector, sector specific, out of basin and contaminated site approaches; a total of 198 actions are listed. Section 4.5 explores approaches to source and environmental monitoring .

This section organizes the nine Lake Superior critical pollutants targeted for reduction into four groups, 1) Mercury, 2) PCBs, 3) Pesticides and 4) Dioxin, HCB and OCS. The reduction strategies that will be pursued in the next 2 to 3 years are presented for each chemical group . Under each strategy, the actions that have been committed to by different Lake Superior government agencies have been listed. These actions in turn are ranked by the number of government agencies that are committing to the action and the level of their commitment.

Accomplishing the pollution prevention and reduction goals that have been established for the nine Lake Superior critical pollutants requires commitment from many entities; tribal, local, state, provincial and federal governments, industry, trade associations and society as a whole, including each individual. This section presents the environmental actions and strategies for the near term that have been selected by the partner agencies involved in the Lake Superior Binational Program to achieve these pollution reductions. While many factors were involved in the selection process, the absence of an agency commitment for any particular agency does not preclude future action.

The bulleted actions listed in this chapter are commitments by the specified agency or organization and are identified by the presence of that organization's acronym following the action. In addition, a numerical ranking follows the organizational acronym to indicate the timeframe this action will be accomplished or initiated within that jurisdiction (for example, EPA(1)).

The agency/organization names and acronyms are:

- EC Environment Canada
- EPA United States Environmental Protection Agency-Region 5 (U.S. EPA)
- MI Michigan Department of Environmental Quality (MDEQ)
- MN Minnesota Pollution Control Agency (MPCA)
- ON Ontario Ministry of Environment (OMOE)
- WI Wisconsin Department of Natural Resources (WI DNR)
- BR Bad River Band of Lake Superior Chippewa
- FDL Fond du Lac Band of Lake Superior Chippewa
- GP Grand Portage Band of Lake Superior Chippewa
- KBIC Keweenaw Bay Indian Community
- RC Red Cliff Band of Lake Superior Chippewa

The ranking of actions that appears in this report is numerical and explained as follows:

(1) Commitments - actions currently supported or planned to be supported by agencies and member organizations within the next two to three years with funds and/or personnel. In some cases, the initial stages of those activities ranked at this level may already have been completed by some of the agencies or partner organizations such as municipalities.

(2) Explore - actions that require additional resources or policy decisions in order to be accomplished or supported. In some cases these actions are as important as those in rank (1) to achieve zero discharge.

Future possibilities - actions that merit inclusion in the LaMP for the purposes of planning, reference and/or future funding considerations.

Actions proposed for commitment at the ranking level of (1) or (2) appear in this chapter; other actions appear in the later sections of this chapter and are denoted as future possibilities. All actions are numbered so that the reader may cross-reference the actions listed in Sections 4.3 and 4.4, which are numbered consecutively.

This section groups actions by the LaMP critical pollutants. For example, the actions proposed to reduce mercury are listed together. Many actions would result in reductions of more than one of the targeted pollutants. These are often repeated in each of the chemical sections below. Some general actions, which could apply to all of the targeted pollutants are listed in Section 4.2.1.5.

4.2.1 Actions and Strategies by Chemical

4.2.1.1 Mercury

Reduction Goals for Mercury

The mercury reduction goals are set out with milestones for 2000, 2010 and 2020. As indicated in Section 4.1, the 2000 milestone for mercury has been met for the basin. In order to meet the 2010 target of 80 percent reduction, emissions and discharges of 2,445 kg/yr in 1990 must be reduced to 489 kg/yr in 2010). The largest emissions are from mining, fuel combustion and commercial products in landfills.

Mercury Commitments

The following seven strategies each include a subset of actions that are ranked as Level 1 or 2:

Strategy 1 - Encourage voluntary reductions of the use, discharge and emission of mercury.

(1) LSBP agencies will work with facilities in the Lake Superior basin to **establish voluntary agreements** to reduce the use, discharge or emissions of the nine designated chemicals in order to meet the goals stated in the stage 2 LaMP reduction schedule. EC(1), EPA(1), MI(1), MN(1), ON(1), WI(1)

(103) LSBP agencies will support and promote implementation of **voluntary agreements with the health care industry** to reduce use of mercury and formation of dioxin. BR(1), EC (2), EPA(1), MI(1), ON(1), WI(1)

(176) The **Great Lakes Binational Toxics Strategy** should be pursued to meet the short-term, interim goals of the Lake Superior Binational Program for mercury. EC(1), EPA(1), MI(1), MN(2)

(104) EPA will continue to contribute resources and expertise to the agency's **voluntary agreement with the American Hospital Association (AHA)**. Under the terms of this agreement, EPA will assist AHA in meeting its goals of virtual elimination of mercury from hospitals by 2005, and a reduction in total solid waste by 33 percent in 2005 and by 50 percent in 2010. EPA will help AHA to disseminate the guidance manuals on mercury and solid waste reduction for this effort by contributing resources to a series of at least six national workshops that will be held by the end of 2001, as well as making all materials available via the Internet. EPA (1)

(79) Assist school districts, education agencies, and youth organizations to **supplement existing curricula and develop new curricula** that are aimed at reducing the nine designated chemicals. This assistance may include training, providing teaching devices, or other necessary activities. EC(1)

(137) By the end of 2000, EPA will publicize, including through posting on its web site, information on how to develop a **mercury reduction plan** at a manufacturing plant. This information will include mercury reduction plans developed at three steel mills under a voluntary agreement between the mills, EPA, the Indiana Department of Environment, and the Lake Michigan Forum. EPA(1)

Strategy 2 - Develop incentives to reduce mercury.

(5) U.S. LSBP agencies will provide indirect or direct **financial support** to businesses, organizations and local governments for pollution prevention projects. Innovation will be encouraged. Possible projects include clean sweeps, bounties on mercury products, bounties or other mechanisms to reduce burn barrel use, mercury swaps for alternative products, education, purchasing policies, energy conservation, water conservation, pay-as-you-throw trash disposal fees and others. BR(1), EPA(1), MI(1), MN(1), WI(1)

(4) U.S. LSBP agencies will evaluate a variety of **economic incentives** or disincentives to promote verifiable or innovative reductions. Possible incentives include early reduction credits, tax relief, low-interest loans, grants, rebates and bounties for achievers. Possible disincentives include fees, taxes or caps on mercury-bearing products or uncontrolled sources of any of the nine designated chemicals. MI(2)

(189) Support federal and state initiatives to provide **incentives to the utility industry** to **develop mercury control technology** and to invest in alternative energy sources. MN(2)

Strategy 3 - The mining and electric utility sectors must reduce mercury by half in order to meet the 2010 milestone.

(22) LSBP agencies will promote **energy conservation programs** (e.g. U.S. Side: EPA Energy Star Program) within the Lake Superior basin, agencies will especially urge the publicly-owned facilities, schools and universities in the Lake Superior basin to participate in energy conservation programs. The agencies will also work with the utilities operating in the basin to coordinate government and utility energy conservation programs. BR(1), EC(2), EPA(1), MI(1), MN(1), ON(1), WI(1)

(114) LSBP agencies will encourage the investigation of **alternative energy** (e.g. low mercury fuels, natural gas, solar, wind) in the Lake Superior basin and encourage residents to purchase energy produced with lower polluting technologies. BR(1), GP(2), MN(2), ON(2)

(23) LSBP agencies will encourage home and industry **energy audits**. BR(1), EC(2), MI(1), ON(1)

(24) LSBP agencies will encourage **municipal energy councils** such as the Thunder Bay 2002 and the Duluth Citizen's Energy Council. EC(2), MN(2), ON(1)

(78) Encourage schools in the Lake Superior basin to commit to **green school programs**, including Energy Star, Blueprint for a Green Campus program, and others. RC(1)

(116) By December 2000, EPA will make a determination about whether to **regulate mercury emissions** from electric utilities. EPA(1)

(93) The Minnesota PCA will identify facilities that use **wet scrubbers** to treat emissions. The quantity of mercury removed by the scrubber will be estimated and the fate of the scrubber water will be investigated. Possible control technologies such as closed loop systems, hot lime precipitation, and others will also be investigated. MN(1)

(120) Promote the long-term goal of having energy utilities **convert from coal burning to a natural gas energy source**. In the medium-term, householders need to develop an energy conservation ethic that would extend to the purchase of clean fuel. RC(2)

(94) The Minnesota PCA will assist the **taconite and electric utility industries** in finding **mercury reduction technologies.** The concentrations of mercury in stack gases from these two sectors is similar enough that the same control technology might be used for both. Assistance may or may not take the form of funding. MN(2)

(96) U.S. LSBP agencies will support experiments to **separate the mercury-bearing pyrite fraction from coal** used in their boilers and stabilization of the resulting byproduct. MN(1)

(25) As part of utility deregulation, the state of Minnesota will consider establishment of a **mandatory "line charge"** for demand side management energy efficiency projects. MN(2)

(26) U.S. LSBP agencies will assist architects and builders in **incorporating energy conservation measures** into new structures being planned and built on the reservation. FDL(1)

(117) The EPA has committed approximately $6 million in FY2000 and FY2001 funds to **support mercury research** in a number of priority areas including transport, transformation and fate; and human health and wildlife effects of methyl mercury. These research activities are aimed at reducing the uncertainties currently limiting the Agency's ability to assess and manage mercury and methyl mercury risks. One particular target of research will be collection and analysis of information on mercury emissions and control options for coal-fired utilities in order to support OAR's mandate for a regulatory determination on mercury controls for utilities by December 15, 2000. EPA(1)

(118) By the end of 2000, EPA will provide funding to **support workshops** in at least one Lake Superior basin state on how to reduce the use of mercury-containing devices at electric utilities. EPA(1)

(95) U.S. LSBP agencies will assist facilities that produce their own electricity from coal-burning to **convert to alternate sources** such as gas turbines. MN(2)

(119) U.S. LSBP agencies will assist utilities in **converting from coal-burning technology**, which releases mercury, to renewable source energy or natural gas technology to produce electricity. MN(2)

Strategy 4 - Mercury-bearing products must be reduced in order to halve the amount of mercury in products by 2010.

(18) LSBP agencies will work with manufacturers within and outside the Lake Superior basin to develop **depots and reverse distribution systems for citizens**. Possible products to include in this strategy include batteries, paints, fluorescent lamps, thermostats, pressure testing equipment, dental amalgam, laboratory reagents and others. EC(1), EPA(1), MI(2), ON(2)

(19) U.S. LSBP agencies will encourage a nationwide dialogue on the import of mercury-bearing products. Nationwide **labeling of mercury products** will also be encouraged. EPA(2), MN(2), MI(1)

(13) U.S. LSBP agencies will evaluate and begin the development of **purchasing policies** to eliminate use of products that might include **mercury equipment or PCB equipment** (e.g., boilers, buildings, vehicles, electrical equipment and laboratory equipment). Policies will also examine phase-out of existing mercury or PCB-containing items. BR(1), MI(1), MN(2)

(105) U.S. LSBP agencies will institute **a mercury thermometer swap program** where mercury thermometers are exchanged for non-mercury-bearing ones. FDL(1), GP(1)

(106) Urge hospitals to discontinue the practice of **sending mercury thermometers home with new mothers** and instead use non-mercury thermometers and distribute information on the hazards of mercury in the home and the actions that families can take to limit their exposure. The agencies will assist in the preparation of these materials. RC(1)

(188) Foster **nationwide product stewardship** and reverse distribution systems with manufacturers. MN(2)

Strategy 5 - Proper identification, collection and disposal of mercury-bearing products in the basin.

(32) LSBP agencies will seek funding to initiate or continue permanent household and agricultural (e.g. pesticides) **hazardous waste (HAHW) collection depots** in the largest Lake Superior basin cities. Furthermore, U.S. LSBP agencies will seek funding to initiate and continue periodic or mobile collections for the more remote locations within the Lake Superior basin. Collections will not be limited to pesticides but will include a focus on mercury containing products (e.g. thermometers, abandoned appliances). U.S. LSBP agencies will seek funding to initiate and continue Lake Superior basin HAHW education programs that will include information about how individuals can practice home environmental stewardship; how to identify HAHW; and how to properly dispose of HAHW. BR(1), EC(2), EPA(1), FDL(1), KBIC(1), MI(1), MN(2), ON(2), RC(1), WI(1)

(100) LSBP agencies will encourage **pollution prevention projects at hospitals**, clinics, and medical, dental, and veterinary offices with an emphasis on removing mercury and making the offices "mercury free." BR(1), EC(1), EPA(1), KBIC(1), MI(1), MN(1), ON(1), WI(1)

(73) LSBP agencies will **assist schools** in seeking out and disposing of mercury and PCBs on school property. BR(1), EPA(1), MI(1), MN(1), ON(1), WI(1)

(101) LSBP agencies will support **partnerships with dental associations** to develop training materials and programs for dental offices regarding the proper handling, collection, and disposal of amalgam wastes. BR(2), EC(1), MI(1), MN(1), ON(1)

(162) LSBP agencies will work with communities to provide **sector-specific pollution prevention outreach** such as workshops for the medical and dental communities, and other important sectors. BR(1), EC(2), EPA (1), MI(1), WI(1)

(187) LSBP agencies will support federal initiatives to **lower the reporting limits on persistent, bioaccumulative toxics under the TRI (US) and the NPRI (Canadian)** and lower the reporting limit for PCBs under TSCA even further in order to track low level waste. BR(1), EC(1), EPA(1), MN(2)

(48) LSBP agencies will evaluate programs to prevent or remove chlorinated or mercury containing material from **incinerator feedstocks.** EC(2), MI(1), ON(1)

(191) The U.S. federal government should consider a plan to **permanently retire its mercury stockpile** and to retire other sources of elemental mercury instead of recycling. EPA(1), MI(2), MN(2)

(20) Canadian LSBP agencies will assist establishing through municipalities **depots for mercury-containing** thermometers, fluorescent tubes and other **household products** about to be discarded. EC(1), ON (1)

(27) Wisconsin and the KBIC will continue to work with local partners to encourage consumer upgrades to energy-efficient programmable electronic thermostats combined with proper disposal of old mercury thermostats. KBIC(1), WI(1)

(51) Canadian LSBP agencies will encourage municipalities to **establish source separation programs** to divert household hazardous materials including cleaners, batteries, and fluorescent lights from landfills or incinerators. EC(1), ON(1)

(107) Canadian LSPB agencies to follow up the 1999 City of Toronto **pilot** among Environment Canada, suppliers and the **Ontario Dental Association** and apply the results to the Thunder Bay area. EC(2), ON(2)

(105) U.S. LSBP agencies will institute a **mercury thermometer swap program** where mercury thermometers are exchanged for non-mercury-bearing ones. FDL(1), GP(1)

(4) U.S. LSBP agencies will evaluate a variety of **economic incentives** or disincentives to promote verifiable or innovative reductions. Possible incentives include early reduction credits, tax relief, low-interest loans, grants, rebates and bounties for achievers. Possible disincentives include fees, taxes or caps on mercury-bearing products or uncontrolled sources of any of the nine designated chemicals. MI(2)

(28) Encourage **re-lamping with fluorescent lamps** and the proper disposal and recycling of old lamps. In addition, the governments will emphasize the proper identification and disposal of PCB ballasts on old fluorescent lamps. KBIC(1)

(75) By the end of 2000, EPA will develop and distribute through the **Binational Toxics Strategy** mercury workgroup a package of information related to mercury reduction at schools, including advice on how to eliminate mercury from school laboratories. EPA(1)

(163) U.S. LSBP agencies will encourage a **source separation program** to divert household hazardous material such as cleaners, batteries, and fluorescent lights from landfills and burn barrels. KBIC(1)

(77) Minnesota will investigate the potential use of a mercury-sniffing dog to **identify mercury** in schools as part of the assistance to schools effort. MN(2)

(180) The U.S. EPA should close the **RCRA Subtitle C loop** that allows the incineration of mercury-bearing hazardous waste. MN(2)

(184) U.S. LSBP agencies will work with operators of **medical waste incinerators** to pursue reductions of mercury, dioxin and hexachlorobenzene through source reduction elimination/segregation, including the removal of noninfectious waste from the incinerator waste stream. BR(1)

Strategy 6 - New laws and regulations may be the most fair way of reducing releases.

(147) U.S. LSBP agencies will pursue **bans on non-essential uses of the nine** persistent, bioaccumulative, toxic substances targeted for zero discharge (e.g. light switches in running shoes). BR(2), MI(2), MN(2)

(149) The states and U.S. EPA will include appropriate limits for persistent bioaccumulative toxic substances in **air emission permits** to eliminate or further reduce the deposition of these substances in the Lake Superior basin. Also, lower emission rates should be used to define major source applicability for MACT standards. MI(1), MN(2)

(148) For toxic pollutants with effluent limitations that are below reliable levels of analytical detection (e.g. nine zero discharge pollutants), U.S. LSBP agencies will require **toxic reduction**

plans in each new or reissued NPDES permit for point sources discharges to the basin. U.S. LSBP agencies will require toxic reduction plans in new or reissued air permits for facilities that could reasonably be expected to emit any of the nine zero discharge pollutants based on knowledge of the process. BR(2), MI(1)

(50) Michigan will evaluate adoption of a law similar to Minnesota's **incinerator law** prohibiting disposal of mercury-bearing waste. MI(1)

(120) Promote the long-term goal of having energy utilities **convert from coal burning to a natural gas energy source**. In the medium-term, householders need to develop an energy conservation ethic that would extend to the purchase of clean fuel. RC(2)

(179) The U.S. Federal government should evaluate lowering the **nationwide limits on sewage sludge and medical waste incinerators**, especially for mercury. MN(2)

(116) By December 2000, EPA will make a determination about whether to **regulate mercury emissions** from electric utilities. EPA(1)

(178) EPA will promulgate regulations requiring **emission limits on pollutants** (such as mercury and dioxin) for all **operating medical waste incinerators** by the end of 2000. All medical waste incinerators that are not equipped to meet these requirements will be required to shut down by the end of 2001. EPA(1)

(108) Ontario will investigate a regulatory **exemption** to dispose of mercury wastes reclaimed from dental offices. ON(2)

(181) Wisconsin DNR will continue to pursue a statewide mercury reduction strategy, including proposed legislation providing for **cap and trade of mercury emissions** in the state. WI(1)

Strategy 7 - Remediation of mercury contaminated sediments.

(126) Pursue clean up of mercury-**contaminated sediments** in Peninsula Harbour through a partnership among public and private organizations. EC(1), ON(2)

4.2.1.2 PCBs

Reduction Goals for PCBs

Because of the inadequacy of the U.S. PCB database in the Lake Superior basin, it is not possible to describe a numeric goal for the mass of PCBs that should be destroyed on the U.S. side of the Lake Superior basin. However, there are a variety of strategies that would both improve the U.S. database and bring about reductions. It is crucial that 1) untested equipment be tested, 2) owners of PCB-bearing equipment decommission that equipment and 3) governments assist their efforts to test and decommission. Section 3.2.11 lists PCB strategies that cover these areas. The section below identifies four PCB strategies that the agencies propose to emphasize in the next two to three years.

In order to meet the 2000 and 2005 PCB reduction goals, Canada will need to destroy a total of 42,391 kg and 131,036 kg, respectively, high level PCBs out of the original 485,320 kg in-use or in-storage in 1990. In addition, reduction estimates for low level PCBs should be improved. Section 4.3.2 contains sector specific strategies that include actions for PCB reductions.

PCB Commitments

The following four strategies each include a subset of actions that are ranked as Level 1 or 2:

<u>Strategy 1 - Encourage voluntary reductions of the use and storage of PCBs</u>.

(1) LSBP agencies will work with facilities in the Lake Superior basin to **establish voluntary agreements** to reduce the use, discharge or emissions of the nine designated chemicals in order to meet the goals stated in the stage 2 LaMP reduction schedule. EC(1), EPA(1), MI(1), MN(1), ON(1), WI(1)

(55) LSBP agencies will encourage **PCB "mentors"**(i.e., facilities that have already removed their PCBs) to assist smaller facilities that do not have access to as much environmental expertise. EC(1), EPA(1), MI(2), MN(2)

(176) The **Great Lakes Binational Toxics Strategy** should be pursued to meet the short-term, interim goals of the Lake Superior Binational Program for PCBs. EC(1), EPA(1), MI(1), MN(2)

(56) LSBP agencies will encourage the formation of **PCB cooperatives** that allow PCB equipment owners to achieve economies of scale by using a common contractor to remove, transport and destroy PCBs from a region within the basin. EC(1), MN(1), ON(1)

(13) U.S. LSBP agencies will evaluate and begin the development of **purchasing policies** to eliminate use of products that might include **PCB or mercury equipment** (e.g., boilers, buildings, vehicles, electrical equipment and laboratory equipment). Policies will also examine phase-out of existing mercury or PCB containing items. BR(1), MI(1), MN(2)

(125) Through voluntary agreements, **remove PCBs** in storage so that all pulp and paper mills are PCB free. EC(1), ON(1)

(65) U.S. LSBP agencies will ask all the power generators in the basin to endorse the **PCB reduction goals** outlined in the Stage 2 LaMP and will provide Lake Superior steward awards to facilities that accept the challenge. EPA(1), MI (2)

(66) By the end of calendar year 2000, EPA will formalize the **PCB Phasedown Program** pilot project with the major electric utilities in the Great Lakes basin, which is designed to encourage the utilities to phase out their remaining PCB equipment. EPA(1)

(2) By the end of calendar year 2006, EPA will work with facilities that have not previously been approached in the Lake Superior basin to establish **voluntary agreements** or commitments to reduce the use or releases of PCBs. EPA(1)

(35) By the end of calendar year 2000, EPA will complete the PCB and Mercury **Clean Sweep pilot project** which includes a component to collect PCB-contaminated oil in the Great Lakes basin, treat the oil to remove the PCBs, and **recycle PCB-free oil**. EPA(1)

Strategy 2 - Untested equipment must be tested and the inventory must be kept current.

(187) LSBP agencies will support federal initiatives to **lower the reporting limits on persistent, bioaccumulative toxics under the TRI (US) and the NPRI (Canadian)** and lower the reporting limit for PCBs under TSCA even further in order to track low level waste. BR(1), EC(1), EPA(1), MN(2)

(62) LSBP agencies will encourage owners of transformers and capacitors to test their equipment to **identify any remaining PCBs**. EPA(1), MI(2), MN(1)

(60) Canadian LSBP agencies will encourage owners of PCB-bearing equipment to monitor and **document the ongoing status** of the equipment until the equipment is removed. EC(1), ON(2)

Strategy 3 - Decommissioning, removal and destruction of PCBs.

(34) U.S. LSBP agencies will seek funding to initiate and continue periodic abandoned **"white goods" collections**. BR(1), FDL(1), GP(1), KBIC(1), MI(2), RC(1)

(58) LSBP agencies will encourage PCB owners to **destroy PCBs** in use or storage. Encouragement could be done through voluntary agreements, economic incentives, or decommissioning in lieu of certain fines. BR(2), EPA(1), MI(2), MN(2), ON(1)

(73) LSBP agencies will **assist schools** in seeking out and disposing of PCBs and mercury that are present on school property. BR(1), EPA(1), MI(1), MN(1), ON(1)

(57) LSBP agencies will include **PCBs in outreach and hazardous waste collections** designed for small businesses since PCBs may be contained in light ballasts, paint, well pumps, small capacitors and white goods (e.g., refrigerators). BR(1), EC(2), EPA(1), MI(2), ON(1)

(63) U.S. LSBP agencies should consider **removal of PCB-bearing equipment** in lieu of some fines (e.g. Supplemental Environmental Projects). BR(2), EPA(1), MI(1)

(61) Canadian LSBP agencies will continue to seek **in-basin PCB destruction capability** for low level PCBs only. EC(1), ON(1)

(151) U.S. LSBP agencies will work with individual facilities in the basin to identify opportunities to **reduce storage, use or release of mercury and PCBs** (e.g., toxic reduction plans, voluntary audits, "check lists" to be included in the permit application.). EPA(1), MI(1)

(64) U.S. LSBP agencies will assist in the **testing and removal of PCB-**bearing equipment, especially for municipalities, schools, hospitals and small businesses. An explanation of the financial consequences of PCB contamination of property should be included in this outreach program. BR(2), MN(2)

(67) By the end of calendar year 2002, EPA **will identify federally-owned PCBs** in the Lake Superior basin and seek their removal by the departments of agencies that own the PCBs. EPA(1)

Strategy 4 - Governments to undertake PCB training programs.

(71) U.S. LSBP agencies will encourage **training sessions for demolition contractors.** Such training would preferably be associated with licensing requirements or other mandatory procedures. Opportunities to align the training with trade association outreach will be sought. BR(2), EPA(2), MI(2), MN(1), WI(1)

(69) LSBP agencies will provide **training materials for appliance recyclers and auto salvage operators** to assist compliance with applicable rules. EC(2), MI(1), MN(1)

(59) Canadian LSBP agencies will consider another round of **training sessions for small PCB owners**. Cooperation is promoted so that PCB owners can reduce the cost of contracted PCB services (e.g., treatment of PCB contaminated mineral oils, on-site decontamination of capacitors and transformers, shipment of PCBs to high temperature incineration facilities and carcass removal). EC(1), ON(1)

4.2.1.3 Pesticides

Reduction Goals for Pesticides

Although U.S. and Canada domestic production has ceased and uses have been canceled, these pesticides continue to have an environmental presence. In addition, the level of toxaphene in Lake Superior has not shown a general decline over the years like the other pesticides. Collection programs in the Lake Superior basin continue to net these pesticides. Lake Superior strategies for pesticides include continued or expanded collection opportunities coupled with concerted public outreach. Strategies for pesticides reductions are discussed in Sections 4.3 and 4.4.

Out-of -basin strategies addressing pesticides would include support by the Great Lakes states and Canada for international efforts such as the Regional Treaty on Persistent Organic Pollutants, the UNEP Global Treaty on Persistent Organic Pollutants, the Commission for Environmental Cooperation Tri-lateral North American Regional Action Plans, and the NAFTA Technical

Working Group on Pesticides to implement phased reduction and eventual elimination of the targeted pesticides in other countries.

Pesticide Commitments

The following three strategies each include a subset of actions that are ranked as Level 1 or 2:

Strategy 1 - Collection of remaining stockpiles of banned pesticides.

(32) LSBP agencies will seek funding to initiate or continue permanent household and agricultural (e.g. pesticides) **hazardous waste (HAHW) collection depots** in the largest Lake Superior basin cities. Furthermore, U.S. LSBP agencies will seek funding to initiate and continue periodic or mobile collections for the more remote locations within the Lake Superior basin. Collections will not be limited to pesticides but will include a focus on mercury containing products (e.g. thermometers, abandoned appliances). U.S. LSBP agencies will seek funding to initiate and continue Lake Superior basin HAHW education programs that will include information about how individuals can practice home environmental stewardship; how to identify HAHW; and how to properly dispose of HAHW. BR(1), EC(2), EPA(1), FDL(1), KBIC(1), MI(1), MN(2), ON(2), RC(1), WI(1)

(5) U.S. LSBP agencies will provide indirect or direct **financial support** to businesses, organizations and local governments for pollution prevention projects. Innovation will be encouraged. Possible projects include **clean sweeps**, bounties on mercury products, bounties or other mechanisms to reduce burn barrel use, mercury swaps for alternative products, education, purchasing policies, energy conservation, water conservation, pay-as-you-throw trash disposal fees and others. BR(1), EPA(1), MI(1), MN(1), WI(1)

(33) U.S. LSBP agencies will assist industries and business in the basin to conduct industrial **clean sweeps** and use economy of scale for collections and shipments of hazardous waste. Examples of successful business collection programs include Western Lake Superior Sanitary District's clean shop program and Northwest Wisconsin Regional Planning Commission's very small quantity generator collection program. BR(2), MI(2), WI(1)

Strategy 2 - Engage other programs that deal with banned pesticides.

(176) The **Great Lakes Binational Toxics Strategy** should be pursued to meet the short-term, interim goals of the Lake Superior Binational Program for pesticides. EC(1), EPA(1), MI(1), MN(2)

(190) The U.S. federal government should tighten **the reporting requirements on export shipments of pesticides**, especially pesticides that are no longer used in the United States. MN(2)

<u>Strategy 3 - Educate residents about the use of pesticides</u>.

(38) LSBP agencies will pursue urban initiatives that increase awareness, through outreach, of the risk of **pesticide use**. EPA(1), ON(2)

(89) Canadian LSBP agencies will encourage **small businesses** through an **education program** to utilize the permanent hazardous waste depots available to them. and coordinate the local **Chamber of Commerce or trade associations** to run pollution prevention education and training sessions for proper **waste management**. EC(2), ON(1)

4.2.1.4 Dioxin, HCB, and OCS

Reduction Goals for Dioxin, HCB, and OCS

While the US and Canada appear to already be ahead of the 80 percent reduction target by 2005 target for dioxin/HCB/OCS, there are gaps in the inventory. As more information becomes available on the sources and loads from the basin, the base line may change, and this may change our estimate of progress towards the 2005 goal. In the meantime, the remaining largest sources of dioxin appear to be burn barrel emissions and wood treatment with pentachlorophenol (PCP). Reduction strategies that should be applied before 2005 include public education and aggressive identification of burn barrels and investigation of ongoing use of PCP and PCP contaminated sites.

Dioxin, HCB, and OCS Commitments

The following five strategies each include a subset of actions that are ranked as Level 1 or 2:

<u>Strategy 1 - Encourage voluntary reductions of the discharge and emission of dioxin/HCB/OCS</u>.

(1) LSBP agencies will work with facilities in the Lake Superior basin to **establish voluntary agreements** to reduce the use, discharge or emissions of the nine designated chemicals in order to meet the goals stated in the stage 2 LaMP reduction schedule. EC(1), EPA(1), MI(1), MN(1), ON(1), WI(1)

(103) LSBP agencies will support and promote implementation of **voluntary agreements with the health care industry** to reduce use of mercury and formation of dioxin. BR(1), EC(2), EPA(1), MI(1), ON(1), WI(1)

(176) The **Great Lakes Binational Toxics Strategy** should be pursued to meet the short-term, interim goals of the Lake Superior Binational Program for dioxin, HCB and OCS. EC(1), EPA(1), MI(1), MN(2)

(178) EPA will promulgate regulations requiring **emission limits** on pollutants (such as mercury and dioxin) for all operating **medical waste incinerators** by the end of 2000. All medical waste

incinerators that are not equipped to meet these requirements will be required to shut down by the end of 2001. EPA(1)

(128) Operational practices and design of existing **wood preservation facilities** in the basin will be assessed in 2000 by third party auditors and Environment Canada will invite facilities to participate in a **voluntary program**. EC(1)

Strategy 2 - Develop incentives to reduce dioxin/HCB/OCS.

(5) U.S. LSBP agencies will provide indirect or direct **financial support** to businesses, organizations and local governments for pollution prevention projects. Innovation will be encouraged. Possible projects include clean sweeps, bounties on mercury products, bounties or other mechanisms to reduce burn barrel use, mercury swaps for alternative products, education, purchasing policies, energy conservation, water conservation, pay-as-you-throw trash disposal fees and others. BR(1), EPA(1), MI(1), MN(1), WI(1)

(166) Establish a recognition program for all wastewater treatment plants that implement the **Blueprint for Zero Discharge**. RC(2)

Strategy 3 - Pollution prevention is the preferred approach to inhibit the formation of dioxin/HCB/OCS in incineration.

(49) U.S. LSBP agencies will support **public education**/outreach campaigns regarding the health and environmental effects of **burn barrels** and small incinerators and encourage local units of government to pass ordinances banning burn barrels. BR(1), EPA(1), FDL(1), MI(1), MN(1), WI(1)

(48) LSBP agencies will evaluate programs to prevent or remove chlorinated or mercury containing material from **incinerator feedstocks.** EC(2), MI(1), ON(1)

(14) LSBP agencies will introduce **process chlorine-free paper products** whenever possible in their communication. KBIC(1), RC(1)

(47) LSBP agencies will insist on the highest standards and best available technology for **new incinerators**. EC(2), EPA(2)

(184) U.S. LSBP agencies will work with operators of **medical waste incinerators** to pursue reductions of mercury, dioxin and hexachlorobenzene through source reduction elimination/segregation, including the removal of noninfectious waste from the incinerator waste stream. BR(1)

(164) EPA has initiated and will continue to work with **developing partnerships between the Hearth Products Association** and any appropriate parties (i.e., state, tribal, local) towards participation in the wood stove change-out program in the Great Lakes basin. This exchange

program allows for the consumer switch from older, less-efficient wood-burning stoves to new more combustion-efficient stoves, which reduces the amount of air toxic emissions. EPA(1)

Strategy 4 - There is a continuing role for the pulp and paper industry to play in dioxin reductions.

(3) Canadian LSBP agencies will continue discussions with the seven **pulp and paper facilities**: to address purchasing policies to eliminate the nine critical pollutants; to review energy reduction practice thereby reducing dependence on purchased energy that is generated from coal burning facilities which release mercury and dioxin; introduce water conservation to reduce energy use; recycle fluorescent tubes. EC(1), ON(1)

(127) Reduce dioxin and furan discharges from the pulp bleaching process by **reducing AOX** to less than 0.8 kg/tonne. ON(1)

Strategy 5 - Identify sources of dioxin/HCB/OCS.

(187) LSBP agencies will support federal initiatives to **lower the reporting limits on persistent, bioaccumulative toxics under the TRI (US) and the NPRI (Canadian)** and lower the reporting limit for PCBs under TSCA even further in order to track low level waste. BR(1), EC(1), EPA(1), MN(2)

4.2.1.5 General Strategies (applicable to several targeted pollutants)

The following four strategies each include a subset of actions that are ranked as Level 1 or 2:

Strategy 1 - Lake Superior goals must be taken into account by other programs.

(199) The EPA and EC will lead efforts to develop a coordinated monitoring strategy for the Lake Superior basin. All of the LSBP agencies will assist in the development of the monitoring strategy and seek resources for implementation. The monitoring strategy will be peer reviewed and presented in LaMP 2002. BR(1), EC(1), EPA(1), FDL(1), GP(1), KBIC(1), MI(1), MN(1), ON(1), RC(1), WI(1)

(176) The **Great Lakes Binational Toxics Strategy** should be pursued to meet the short-term, interim goals of the Lake Superior Binational Program for mercury, PCBs, dioxin, hexachlorobenzene, octachlorostyrene, and pesticides. EC(1), EPA(1), MI(1), MN(2)

(144) LSBP agencies will coordinate LaMP critical pollutant reduction strategies with **Total Maximum Daily Load requirements** or limits under Ontario's Certificate of Approval process. FDL(1), MN(1), ON(1)

(145) EPA will provide technical and regulatory assistance to Lake Superior basin States, Tribes, and local governments on how to **identify and address Class V** wells that may endanger

groundwater within the Lake Superior basin and therefore pose a contamination threat to the waters of Lake Superior. EPA(1)

(146) EPA will provide priority review to potentially endangering and **high priority Class V well types** identified within delineated source water protection areas for Lake Superior public drinking water system intakes in Michigan and Minnesota. EPA(1)

(156) Minnesota will consider the applicability of the **Outstanding National Resource Water (ONRW) designation** in future reviews of water quality rules. MN(1)

(78) Encourage schools in the Lake Superior basin to commit to **green school programs** including Energy Star, Blueprint for a Green Campus program and others. RC(1)

(182) U.S. LSBP agencies will work on a cooperative basis to establish a **national ambient air toxics monitoring network.** This network can be used to determine atmospheric deposition of toxics and assess multi-pathway exposures to air emissions such as the bioaccumulation of methylmercury in fish resulting in exposures to people who eat fish. WI(1)

(183) U.S. LSBP agencies will continue to participate in the **Great Lakes Regional Air Toxics Emissions Inventory** to compile a database of point, area, and mobile source emissions for the Great Lakes region. WI(2)

(152) Ontario will actively pursue the development of regulations to require **monitoring and reporting emissions**, of public concern, from significant industrial and commercial emission sources. ON(1)

Strategy 2 - Sites contaminated by the nine designated chemicals must be identified and cleaned up.

(194) LSBP agencies will **initiate necessary sediment remediation measures at AOCs** and other impaired sites known to contribute persistent, bioaccumulative substances to the Lake Superior ecosystem. EC(1), MN(2), ON(2), WI (2)

(168) Canadian LSBP agencies will support First Nations on contaminated **site assessment and remediation** (primarily petroleum hydrocarbon contamination). EC(1)

(195) The Superfund program is currently working to **complete remediation** at two sites in the Lake Superior basin. These include **Torch Lake** in Michigan and the **St. Louis River** in Minnesota. Superfund commits to completing the remedies for these two sites by the end of FY 2005. EPA(1)

<u>Strategy 3 - Pollution prevention is the preferred approach to achieving the goal of zero discharge</u>.

(165) Pursue funding for a public awareness campaign in support of the community toxic reduction activities. The **P2 awareness campaign** should focus on preventing pollution in the home, conserving energy, using alternative products, encouraging use of clean sweep collections and other proper disposal of household hazardous wastes. Elements of the campaign could include a brochure for owners of old homes on how to dispose of banned and outdated products, and a "Get rid of it" brochure for the "nasty nine" chemicals. Consumer groups will be sought as partners in this strategy. FDL(1), RC(1)

(141) Canadian LSBP agencies will **expand the Pollution Prevention Demonstration Site Program** to both Canadian Federal facilities and First Nations in the Lake Superior drainage basin. The program addresses the generation of hazardous waste through such activities as identification and demonstration of alternative products, practices and technologies. EC(2)

(87) By the end of 2000, EPA will publicize through posting on its web site, information on how owners and operators of motor vehicle **waste disposal wells** can comply with the revisions to the Underground Injection Control Regulations that become effective on April 5, 2000. This information will assist these small businesses located in the Lake Superior basin to reduce or eliminate discharges that may adversely impact area groundwater that may ultimately flow into the lake. EPA(1)

(167) Canadian LSBP agencies will support initiatives to **reduce reliance on petroleum hydrocarbons for energy production** or space heating purposes at First Nations (use of alternative technologies/green power). EC(2)

(150) States and U.S. EPA will include **pollution prevention components in enforcement settlements** as appropriate. MI(1)

(21) The province of Ontario will investigate the **feasibility of redrafting existing legislation** to accommodate product stewardship strategies involving waste disposal. ON(2)

(78) Encourage schools in the Lake Superior basin to commit to **green school programs** including Energy Star, Blueprint for a Green Campus program, and others. RC(1)

(26) U.S. LSBP agencies will assist architects and builders in incorporating **energy conservation measures into new structures** being planned and built on the reservation. FDL(1)

(163) U.S. LSBP agencies will encourage a **source separation program** to divert household hazardous material such as cleaners, batteries, and fluorescent lights from landfills and burn barrels. KBIC(1)

U.S. Action:

(138) WDNR will work with the region's oil refining industry to evaluate use, generation, and environmental release of Lake Superior critical pollutants and investigate options for pollution prevention and control. WI(2)

Strategy 4 - Lake Superior communities must be supported in their pursuit of the zero discharge demonstration program and encouraged to share their expertise to help others protect the Lake.

(76) U.S. LSBP agencies will support basin-wide coordination of citizen and school monitoring programs such as "**Lake Superior Lakewatch**." U.S. LSBP agencies will support continuations of existing programs and formation of new programs based on local interest. These programs will be used as outreach activities for the Binational Program and will increase a sense of stewardship in the Lake Superior basin. BR(2), FDL(1), WI(2)

(88) U.S. LSBP agencies will pursue **funding for community and regional toxic reduction activities** and networking between Lake Superior communities. In particular, the toxic reduction committees working in Marquette, Michigan; Superior, Wisconsin; and through the Western Lake Superior Sanitary District (WLSSD) in Duluth, MN, should be supported. Innovative and alternative funding should also be pursued for these and expanded efforts in communities throughout the Lake Superior basin. BR(1), WI(1)

(79) Assist school districts, education agencies, and youth organizations to **supplement existing curricula and develop new curricula** that are aimed at reducing the nine designated chemicals. This assistance may include training, providing teaching devices, or other necessary activities. EC(1)

4.3 REDUCTION STRATEGIES BY SECTOR

The previous section presented strategies and actions organized by critical pollutants. This section is organized by socioeconomic sectors. The purpose of the Lake Superior Stage 3 LaMP is to identify strategies that will reduce critical pollutants in accordance with Stage 2 load reduction schedules, with the ultimate goal being the virtual elimination of critical pollutant inputs to the environment. There are several broad categories of strategies, including Contaminated Sites Strategies (Section 4.4) and Monitoring Strategies (Section 4.5). This section covers strategies aimed primarily to reduce loads from sources within the Lake Superior basin. They are grouped into the following sections: Multiple Sector Strategies, Sector Specific Strategies, and Out-of-basin Strategies. The latter identifies actions that could be taken on a broader scale to protect Lake Superior from airborne contaminants.

This section presents actions that were selected as agency commitments, as well as actions that have been discussed through the Lake Superior Binational Program, but are not proposed as commitments at this time. These actions are included and denoted under the heading "future possibilities." Some of these are important if load reduction goals in 2005 and 2010 are to be met.

The government agencies working on the Binational Program are selecting various actions to pursue in the coming two to three years. Strategies listed in this section are denoted as commitments by the following acronyms.

EC Environment Canada (EC)

EPA United States Environmental Protection Agency – Region V (U.S. EPA)

MI Michigan Department of Environmental Quality (MDEQ)

MN Minnesota Pollution Control Agency (MPCA)

ON Ontario Ministry of Environment (OMOE)

WI Wisconsin Department of Natural Resources (WI DNR)

BR Bad River Band of the Lake Superior Chippewa

FDL Fond du Lac Band of the Lake Superior Chippewa

GP Grand Portage Band of the Lake Superior Chippewa

KBIC Keweenaw Bay Indian Community

RC Red Cliff Band of the Lake Superior Chippewa

Lake Superior Binational Program agencies are indicated in the text as LSBP agencies. Some of these strategies can be pursued with existing resources, although many would require additional resources in order to be accomplished. In this chapter, strategies that are not accompanied by agency acronyms in the listing are included for future reference but are not proposed as commitments at this time.

4.3.1 Multiple Sector Strategies

Some reduction strategies are applicable to nearly all sectors of society (industry, business, government, and communities). For example, energy conservation can be applied to every sector. Similarly, the same pollution control technology may be used by different sectors, and the same government programs may apply to a variety of sectors. The following reduction strategies are recognized for their broad applicability to multiple sectors.

4.3.1.1 Voluntary Agreements

Regulatory measures provide only part of the reductions needed to meet the zero discharge and zero emission challenge. Voluntary agreements to reduce discharges and emissions beyond the legally required limits are needed to fill the gap between mandatory reductions and virtual elimination (e.g., zero release). The voluntary agreement approach is already being used in several LSBP agencies and it is proposed that this effort be emphasized in the Lake Superior Binational Program. Industries in the basin would be asked to respond to the goals of the zero discharge program. The success of voluntary agreements could be evaluated in three ways: 1) the reduction in releases of mercury, dioxin, HCB and OCS beyond the compliance limits; 2) the amount of PCBs decommissioned from a voluntary agreement facility; or 3) the number of facilities that participate in a voluntary agreement.

Binational Action:

(1) LSBP agencies will work with facilities in the Lake Superior basin to establish voluntary agreements to reduce the use, discharge or emissions of the nine designated chemicals in order to meet the goals stated in the Stage 2 LaMP reduction schedule. (EC, EPA, MI, MN, ON, WI)

U.S. Action:

(2) By the end of calendar year 2006, EPA will work with facilities that have not previously been approached in the Lake Superior basin to establish voluntary agreements or commitments to reduce the use or releases of PCBs. (EPA)

Canadian Action:

(3) Canadian LSBP agencies will continue discussions with the seven pulp and paper facilities: to address purchasing policies to eliminate the nine critical pollutants; to review energy reduction practice thereby reducing dependence on purchased energy that is generated from coal burning facilities which release mercury and dioxin; introduce water conservation to reduce energy use; recycle fluorescent tubes. (EC, ON)

4.3.1.2 Economic Incentives, Evaluation and Assistance

There can be an economic cost associated with zero discharge and zero emission. Some sources will be easier and cheaper to reduce while others will be more difficult and expensive. Developing and compiling information on the cost effectiveness would be beneficial in choosing reduction activities because the most cost-effective reductions should be implemented first. In addition, the governments should consider what economic incentives could be used to encourage reductions and how to provide sector- specific support and guidance to sources that have significant releases, but lack the resources to implement reductions. Progress on these economic strategies could be measured in a variety of ways. Some examples of measurement could be: 1) cost effectiveness information compiled for the strategies in this Stage 3; 2) quantity of the nine designated chemicals that are avoided through implementation of strategies; or 3) number and size of loans or grants in some jurisdictions for programs that reduce the nine designated chemicals.

U.S. Actions:

(4) U.S. LSBP agencies will evaluate a variety of economic incentives or disincentives to promote verifiable or innovative reductions. Possible incentives include early reduction credits, tax relief, low-interest loans, grants, rebates and bounties for achievers. Possible disincentives include fees, taxes or caps on mercury-bearing products or uncontrolled sources of any of the nine designated chemicals. (MI)

(5) U.S. LSBP agencies will provide indirect or direct financial support to businesses, organizations and local governments for pollution prevention projects. Innovation will be encouraged. Possible projects include clean sweeps, bounties on mercury products, bounties or other mechanisms to reduce burn barrel use, mercury swaps for alternative products, education, purchasing policies, energy conservation, water conservation, pay-as-you-throw trash disposal fees and others. (BR, EPA, MI, MN, WI)

Future possibilities:

(6) Compile a running list of the cost effectiveness of the reduction strategies. Sources of information pertaining to cost effectiveness include the Minnesota Mercury Initiative Strategies Report, the Canadian Pollution Prevention Centre in Sarnia, the Lake Superior Energy Efficiency report (Wisconsin Energy Conservation Corporation 1998), and facility-specific environmental review documents.

(7) Investigate the establishment of a fund to assist in reduction, remediation, treatment, disposal and safe storage of the nine designated chemicals. The source of the funding could be from both the public and private sectors.

(8) Undertake an assessment of the utility of various economic instruments for the municipal and industrial sectors of the Lake Superior watershed.

(9) Continue to explore alternative financing arrangements for environmental protection and restoration (e.g. revolving loan funds).

(10) In Canada, investigate the feasibility of a program to waive the federal GST or Provincial sales tax on environmentally friendly products.

4.3.1.3 Other Incentives

While economic incentives are important, there are other types of incentives that should be used in the Zero Discharge Demonstration Project. Examples of other incentives include awards and credit for beyond-compliance reductions. Possible measures of success for this strategy could include the total pounds of pollution avoided during a given year, or the number of facilities each year that meet established criteria.

Future possibilities:

(11) In cooperation with the Lake Superior Binational Forum, LSBP agencies will establish a Lake Superior steward project. A special effort will be made to identify suppliers of products that are free of mercury, dioxin, and HCB.

(12) Acknowledge credit for beyond-compliance reductions, in order to provide an incentive for basin facilities to voluntarily reduce the use and emissions of the nine critical pollutants. The purpose of these credits is to avoid penalizing facilities that have already achieved reductions before nation-wide reduction programs are established.

4.3.1.4 Purchasing Policies

Much of the effort to reduce the nine designated chemicals will take place at the chemical's point source. However, the role of consumers should not be underestimated. Consumer purchases can influence the production and use of the nine designated chemicals. The governments themselves are significant consumers and government purchasing policies can set an example. Measuring progress towards this strategy could be determining the number of entities that develop purchasing policies on a before-and-after comparison of purchases. Also, calculations of quantities of critical pollutants avoided due to product switching could be estimated.

U.S. Action:

(13) U.S. LSBP agencies will evaluate and begin the development of purchasing policies to eliminate use of products that might include mercury equipment or PCB equipment (e.g., boilers, buildings, vehicles, electrical equipment and laboratory equipment). Policies will also examine phase-out of existing mercury or PCB containing items. (BR, MI, MN)

(14) LSBP agencies will introduce process chlorine-free paper products whenever possible in their communication. (KBIC, RC)

Future possibilities:

(15) Canadian LSBP agencies will work with pulp and paper mills to develop purchasing policies that require the certification of feedstock materials and confirm that levels of the nine critical pollutants are extremely low (concentration to be determined).

(16) Encourage facilities that use feedstock chemicals such as caustic soda, potassium hydroxide, sodium hypochlorite, sulfuric acid, chlorinated solvents, pesticides, analytic reagents or preservatives to develop purchasing policies to avoid purchasing chemicals that contain mercury, dioxin or hexachlorobenzene, even in trace amounts. Facilities would develop strategies to purchase products proven to be free of the nine critical pollutants. The nine critical pollutants should not be used or discharged in the manufacture of purchased products. Chemical suppliers who provide clean chemical products could get an award through the proposed Lake Superior steward program.

(17) Contract to print Lake Superior Binational Program documents with printers who participate in the Great Printers Project.

4.3.1.5 Product Stewardship

Product stewardship includes designing, manufacturing, transporting, retailing and disposal of products with the intent to minimize the impact of products to the environment. A variety of product stewardship programs are already in use by manufacturers. At this time these programs focus on the waste management portion of the product life cycle. Examples include programs that provide for thermostats to be returned to manufacturers for mercury recycling. Other possible product stewardship strategies include disposal depots maintained by manufacturers and labeling of products that contain critical pollutants. Of the nine designated chemicals, this strategy will be most applicable to mercury because of its many different uses. Possible measures of success for product stewardship include the number of companies labeling mercury-bearing products used in the Lake Superior basin, the weight of products brought into depots or returned through a reverse distribution system.

Binational Action:

(18) LSBP agencies will work with manufacturers within and outside the Lake Superior basin to develop depots and reverse distribution systems for citizens. Possible products to include in this strategy include batteries, paints, fluorescent lamps, thermostats, pressure-testing equipment, dental amalgam, laboratory reagents and others. (EC, EPA, MI, ON)

U.S. Action:

(19) U.S. LSBP agencies will encourage a nationwide dialogue on the import of mercury -bearing products. Nationwide labeling of mercury products will also be encouraged. (EPA, MN, MI)

Canadian Actions:

(20) Canadian LSBP agencies will assist in establishing depots for old mercury-containing thermometers, fluorescent tubes and other products for households. (EC, ON)

(21) The province of Ontario will investigate the feasibility of redrafting existing legislation to accommodate product stewardship strategies involving waste disposal. (ON)

4.3.1.6 Energy Conservation

Burning fossil fuels, particularly coal, to produce energy releases mercury and dioxin into the atmosphere. Fuel combustion is the second largest source of mercury emissions within the Lake Superior basin, but it is a relatively small source of dioxin. Control technologies are not currently available to substantially reduce mercury emissions from this source. Energy conservation would decrease the demand for energy, lower the amount of fuel burned, and thus reduce mercury emission. An additional significant benefit of this strategy is that it provides economic savings for the participants.

However, since energy is not necessarily used where it is produced, a decrease in energy used in the basin will not automatically result in decreased emissions. The Lake Superior utilities will still be able to sell their energy to other customers outside the basin. Despite this drawback, energy conservation in the basin is still valuable as a demonstration to be emulated outside the region.

The area of energy conservation and demand side management has been explored through the Lake Superior Energy Efficiency Work Group (Wisconsin Energy Conservation Group 1998). Energy conservation is also recommended in the Lake Superior Binational Program P2 Strategy (1996). A variety of other programs deal exclusively with the use of energy conservation to lower bills and promote environmentally friendly homes and businesses. One such program is the U.S. EPA Energy Star program. Several organizations in the Lake Superior basin are current participants in this program.

Water efficiency can also affect energy conservation. Work in the U.S. and Canada has shown that water conservation programs can have a beneficial impact on wastewater treatment plant performance. Water conservation can lead to increased performance and efficiency of treatment plants and decreased energy use, leading to reduction in operation and maintenance costs.

Measures of progress for energy conservation could include: 1) tracking trends in per capita electrical consumption in the basin compared to other regions; 2) the number of businesses enrolled in programs such as Energy Star; and 3) the ratio of fluorescent lamps to incandescent lamps sold in the basin. This type of information can often be translated into amount of energy saved, dollars saved and amount of mercury emissions that were prevented.

Binational Actions:

(22) LSBP agencies will promote energy conservation programs (e.g. on the U.S. side: EPA Energy Star Program) within the Lake Superior basin, agencies will especially urge the publicly-owned facilities, schools and universities in the Lake Superior basin to participate in energy conservation programs. The agencies will also work with the utilities operating in the basin to coordinate government and utility energy conservation programs. (BR, EC, EPA, MI, MN, ON, WI)

(23) LSBP agencies will encourage home and industry energy audits. (BR, EC, MI, ON)

(24) LSBP agencies will encourage municipal energy councils such as the Thunder Bay 2002 and the Duluth Citizen's Energy Council. (EC, MN, ON)

U.S. Action:

(25) As part of utility deregulation, the state of Minnesota will consider establishment of a mandatory "line charge" for demand side management energy efficiency projects. (MN).

(26) U.S. LSBP agencies will assist architects and builders in incorporating energy conservation measures into new structures being planned and built on the reservation. (FDL)

(27) Wisconsin and the KBIC will continue to work with local partners to encourage consumer upgrades to energy-efficient programmable electronic thermostats combined with proper disposal of old mercury thermostats. (KBIC, WI)

(28) Encourage re-lamping with fluorescent lamps and the proper disposal and recycling of old lamps. In addition, the governments will emphasize the proper identification and disposal of PCB ballasts on old fluorescent lamps. (KBIC)

Future possibilities:

(29) Encourage large electrical consumers (facilities) to use federal and provincial energy audit programs.

(30) Encourage utilities to conduct special promotions of their energy conservation programs within the Lake Superior basin.

(31) Encourage utilities to send mercury awareness and energy conservation information to consumers with monthly utility bills.

4.3.1.7 Waste Collection

Many household and agricultural products contain mercury and/or other LSBP defined critical pollutants, which could be eventually released to the environment. Within the Lake Superior basin, collection of household and agricultural products that contain mercury or other critical pollutants should be reasonably available to all basin residents. In addition, the Stage 2 LaMP reduction goals for pesticides are based on the operation of agricultural product collections. Most collections are publicly funded programs to collect household and agricultural hazardous waste and recycle or dispose of it properly.

In 1998, the City of Superior, Wisconsin Toxic Reduction Committee evaluated the availability and effectiveness of household hazardous waste and agricultural pesticide collection programs in the Lake Superior basin. This work is summarized below. Collection programs in the Lake Superior basin face challenges of funding and efficiency in serving a largely rural and scattered population. Generally single-event collections are the most expensive. Mobile collection programs have been found to be more cost-effective in some parts of the Lake Superior basin, such as in Wisconsin where a program is operated by the Northwest Wisconsin Regional Planning Commission. Permanent collection facilities operate in some of the larger population centers of the basin. Some areas of the basin are under-served.

In Michigan, Minnesota, and Wisconsin, household hazardous waste collection programs are usually coordinated in some way by county government. In both Minnesota and Wisconsin, all Lake Superior basin counties have ongoing collection programs. In Duluth, Minnesota there is also a permanent collection program operated by Western Lake Superior Sanitary District. Except for Marquette County, Michigan's Lake Superior counties do not have on-going collection programs. The upper peninsula of Michigan has two permanent collection locations in

Marquette and Escanaba. Canadian residents of the Lake Superior basin experience a lesser availability of household hazardous waste collection programs. In Canada, two clean sweeps were attempted in the early 1980s for recently banned organochlorine pesticides. They were found to be an inefficient way to collect these materials and the initiative was replaced with permanent household hazardous waste depots operating seasonally in Thunder Bay. Thunder Bay is the only Canadian municipality within the basin that has an ongoing collection program.

Usage statistics from ongoing programs indicate that collection events are well attended and that participation has increased from year to year. In addition, local government officials report that they receive many inquiries for proper household hazardous waste disposal in areas where collections are not available.

Agricultural “clean sweeps” are an important element of these collections. Surprising volumes of DDT, chlordane, and toxaphene have been collected at events in the U.S. portion of the basin, even though it is not an agriculture-intensive area.

In 1995, Northwest Wisconsin Regional Planning Commission, a local planning organization, developed a mobile household and agricultural hazardous waste collection program. It is funded by a combination of state and local monies, user fees, and pesticide assessment fees. In 1999, an EPA grant provided additional funds for outreach and expansion activities. The goal of this outreach was to educate people on how their personal actions affect the Lake Superior ecosystem. Preliminary indications are that the expanded outreach has doubled participation in the program.

In the late 1990s several tribes (Bad River Band, Fond Du Lac Band, Keweenaw Bay Indian Community, Grand Portage Band) have conducted collections in communities in and around reservation lands. A strong advertising and educational campaign prior to initiating a collection was found to be a valuable tool. Some tribes offered a limited pick-up service for individuals (e.g. elders) unable to leave their home to deliver material. Household hazardous waste collections implemented by tribes have been funded by a combination of federal and tribal government funding.

A broad indication of success for collection programs is whether collection opportunities are reasonably available to most basin residents. Success of individual programs can be monitored using collection quantities and number of households using the service.

Binational Action:

(32) LSBP agencies will seek funding to initiate or continue permanent household and agricultural (e.g. pesticides) hazardous waste (HAHW) collection depots in the largest Lake Superior basin cities. Furthermore, U.S. LSBP agencies will seek funding to initiate and continue periodic or mobile collections for the more remote locations within the Lake Superior basin. Collections will not be limited to pesticides but will include a focus on mercury containing products (e.g. thermometers, abandoned appliances). U.S. LSBP agencies will seek funding to initiate and continue Lake Superior basin HAHW education programs that will include information about how individuals can practice home environmental stewardship; how to identify HAHW and properly dispose of HAHW, and how this protects the Lake Superior basin. (BR, EC, EPA, FDL, KBIC, MI, MN, ON, RC, WI)

U.S. Actions:

(33) U.S. LSBP agencies will assist industries and business in the basin to conduct industrial clean sweeps and use economy of scale for collections and shipments of hazardous waste. Examples of successful business collection programs include Western Lake Superior Sanitary District's clean shop program and the Northwest Wisconsin Regional Planning Commission's very small quantity generator collection program. (BR, MI, WI).

(34) U.S. LSBP agencies will seek funding to initiate and continue periodic abandoned "white goods" collections. (BR, FDL, GP, KBIC, MI, RC)

(35) By the end of calendar year 2000, EPA will complete the PCB and mercury Clean Sweep pilot project, which includes a component to collect PCB-contaminated oil in the Great Lakes basin, treat the oil to remove PCBs, and recycle PCB-free oil. (EPA)

Future possibilities:

(36) Investigate the use of a surcharge or assessment at the wholesale or retail level on mercury-containing consumer items to fund collection programs.

(37) Develop a more holistic approach to waste collection on the reservation. (FDL)

4.3.1.8 Pesticide Use

In the United States, the pesticides designated for the Lake Superior zero discharge demonstration program (aldrin/dieldrin, chlordane, DDT and toxaphene) have been canceled (i.e., production is legal, sale and distribution is illegal, but application/use of designated pesticides purchased prior to cancellation is legal). In addition, these designated pesticides, with the exception of chlordane, have not been in production in the U.S. for many years. In 1997, the only remaining U.S. manufacturer of chlordane announced that their production would cease.

In Canada, federal registration for production of aldrin/dieldrin and chlordane has been discontinued in 1990 with the whole and retail sale of end-use products being permissible until 1995. Federal registration for DDT was discontinued in 1985 with permissible use until 1990.

The use of toxaphene was suspended in 1980 with retail sale permitted until 1985. Provincially these pesticides have been banned.

While both countries have ceased production, sale and distribution of these pesticides, these pesticides continue to have an environmental presence. Their continued presence in the environment can be attributed to the pesticides' persistence in the environment and the large amounts of these pesticides that were used during the 1960's and 1970's. Furthermore, pesticide collection activities in the basin have found that these canceled pesticides are still in the possession of some individuals. Global and residual regional usage will continue to contribute to the atmospheric deposition of these pesticides in the Lake Superior basin. Current contamination levels of the designated pesticides remain a concern as reflected by water concentrations that exceed U.S. national water quality standards, sediment concentrations that exceed sediment guidelines, and fish consumption advisories in both countries.

Although approximately 75 percent of the usage of registered pesticides (which can contain, as a contaminant, small amounts of dioxin or hexachlorobenzene) is for agricultural purposes, non-agricultural uses of pesticides also impact the basin. Pesticides are universally applied to urban landscaping, residential and commercial property, golf courses, university property and governmental property. The information regarding land-usage and pesticide application is complicated by the fact that research does not suggest a precise relationship between the amount of pesticides applied and the environmental fate of these pesticides.

A broad approach to the virtual elimination of the designated pesticides would combine community education, outreach, cooperation, promotion of clean sweeps, and information regarding available alternatives with respect to the targeted pesticides. Measures of progress could include the amount of pesticides collected, the number of people participating in collections, and the use of pesticide educational materials.

Binational Actions:

(32) LSBP agencies will seek funding to initiate or continue permanent household and agricultural (e.g. pesticides) hazardous waste (HAHW) collection depots in the largest Lake Superior basin cities. Furthermore, U.S. LSBP agencies will seek funding to initiate and continue periodic or mobile collections for the more remote locations within the Lake Superior basin. Collections will not be limited to pesticides but will include a focus on mercury containing products (e.g. thermometers, abandoned appliances). U.S. LSBP agencies will seek funding to initiate and continue Lake Superior basin HAHW education programs that will include information about how individuals can practice home environmental stewardship; how to identify HAHW and properly dispose of HAHW, and how this protects the Lake Superior basin. (EC, EPA, MI, MN, ON, WI, BR, FDL, KBIC, RC)

(38) LSBP agencies will pursue urban outreach initiatives that increase awareness, through outreach, of the risk of pesticide use. (EPA, ON)

Future possibilities:

(39) Work with the USDA to promote the environmental benefits of the agricultural use of low risk pesticides in protecting the soil and water.

(40) Distribute information from the EPA's Pesticide Environmental Stewardship Program including:

- Acceleration of the registration of low risk pesticides, the use of naturally-occurring biologically produced pesticides and the use of plants genetically engineered with resistance to pests are also viable options.

- Annual grants to researchers to develop low risk pesticides or to reduce the use of pesticides.

- An urban initiative that increases awareness, through outreach, of the risk of pesticide use. (EPA, ON)

(41) Address continued international production and usage of these pesticides through existing global/international initiatives.

(42) Continue communication and encourage reporting between the LSBP and the Binational Toxics Strategy on the issue of the long-range transport of pesticides.

(43) Confirm that pesticides of concern are no longer used in the basin and eliminate any illegal uses.

(44) Develop disposal projects for pesticides used for snow mold control at golf courses.

(45) Assist municipalities in improving pretreatment programs to detect and help eliminate trace sources of mercury, PCBs, and pesticide releases discharging into sewerage systems.

(46) Encourage dialogue with sectors using chlorinated pesticides regarding the practice of burning vegetative residues.

4.3.1.9 Solid Waste Management

Proper solid waste (garbage) management can decrease release of zero discharge chemicals like dioxin and mercury. Mercury containing products disposed with other solid waste has a high potential of being released into the environment either by vaporization, leaching, or incineration. Solid waste incineration is also a source of dioxin. According to the Stage 2 LaMP, small inefficient waste incinerators were estimated to be a major source of dioxin to the atmosphere. Examples of these incinerators include those used in grocery stores, apartment buildings, and schools. Since 1990, restrictions on air emissions have precluded the legal operation of most inefficient incinerators in the Lake Superior basin. Backyard garbage burn barrels are another source that is estimated to be a major contributor of dioxin to the atmosphere. Burn barrels may be a particularly important dioxin source in the primarily rural Lake Superior basin. Burn barrel use has been curtailed in some areas through public education and local ordinances. One example of which is within the Red Cliff Indian reservation located on the Bayfield Peninsula of the Wisconsin portion of the Lake Superior basin the Red Cliff tribe's Housing Authority has a policy in place that prohibits the use of burn barrels by Housing Authority tenants. Compliance depends on the availability of inexpensive and convenient alternatives. Enforcement depends on local desires. Public education is an important step.

The solid waste management philosophy of "reduce, reuse, recycle," serves to help accomplish the pollutant load reduction targets for Lake Superior. Progress on the Lake Superior goals related to solid waste management could be judged in the following ways: 1) the number of local units of government with burn barrel ordinances, 2) estimates of actual burn barrel use; 3) availability of recycling programs to basin residents, and 4) the amount of mercury-containing waste disposed in landfills.

Binational Actions:

(47) LSBP agencies will insist on the highest standards and best available technology for new incinerators. (EC, EPA)

(48) LSBP agencies will evaluate programs to prevent or remove chlorinated or mercury containing material from incinerator feedstocks. (EC, MI, ON)

U.S. Actions:

(49) U.S. LSBP agencies will support public education/outreach campaigns regarding the health and environmental effects of burn barrels and small incinerators and encourage local units of government to pass ordinances banning burn barrels. (BR, EPA, FDL, MI, MN, WI)

(50) Michigan will evaluate adoption of a law similar to Minnesota's incinerator law prohibiting disposal of mercury-bearing waste. (MI)

Canadian Action:

(51) Canadian LSBP agencies will encourage municipalities to establish source separation programs to divert household hazardous materials including cleaners, batteries, and fluorescent lights from landfills or incinerators. (EC, ON)

Future possibilities:

(52) Develop a universal waste rule under RCRA authority that applies to a wider variety of mercury-bearing products.

(53) Encourage a nationwide ban on small incinerators.

(54) Develop a plastics recycling program in the basin.

4.3.1.10 PCB Phaseout

Although manufacture of PCBs was banned in 1977, the pressure and heat tolerance characteristics of PCBs results in old PCB-bearing equipment (capacitors and transformers) still being used in the Lake Superior basin. This includes high level equipment (>500 ppm in the US, >10,000 ppm in Canada) where PCBs were deliberately used and low level equipment (>500 ppm in Canada) where PCBs contaminated the oil during testing, refilling or maintenance. In addition, considerably smaller quantities of PCBs can be found in older household products and some other types of equipment.

This equipment is used by a variety of sectors including industry, electric utilities and municipal utilities. The U.S. EPA has urged Great Lakes utilities to accelerate phase-out of PCB-bearing equipment. In Canada, the Canadian Environmental Protection Act gives consideration to the legislative phase-out of in-use electrical equipment containing PCBs. The Province of Ontario has encouraged all PCB owners to decommission the large amount of PCB equipment that was in storage in the Lake Superior basin. Large amounts of PCBs are still contained in the basin, however precise quantities have been difficult to establish. Progress can be measured by monitoring the number of facilities that have tested their equipment and by the amount of PCB equipment that has been decommissioned.

Binational Actions:

(55) LSBP agencies will encourage PCB “mentors” (i.e., facilities that have already removed their PCBs) to assist smaller facilities that do not have access to as much environmental expertise. (EC, EPA, MI, ON, MN)

(56) LSBP agencies will encourage the formation of PCB cooperatives that allow PCB equipment owners to achieve economies of scale by using a common contractor to remove, transport and destroy PCBs from a region within the basin. (EC, MN, ON)

(57) LSBP agencies will include PCBs in outreach and hazardous waste collections designed for small businesses since PCBs may be contained in light ballasts, paint, well pumps, small capacitors and white goods (e.g., refrigerators). (BR, EC, EPA, MI, ON)

(58) LSBP agencies will encourage PCB owners to destroy PCBs in use or storage. Encouragement could be done through voluntary agreements, economic incentives, and decommissioning in lieu of certain fines. (BR, EPA, MI, MN, ON)

Canadian Actions:

(59) Canadian LSBP agencies will consider another round of training sessions for small PCB owners. Cooperation is promoted so that PCB owners can reduce the cost of contracted PCB services (e.g. treatment of PCB contaminated mineral oils, on-site decontamination of capacitors and transformers, shipment of PCBs to high temperature incineration facilities and carcass removal). (EC, ON)

(60) Canadian LSBP agencies will encourage owners of PCB-bearing equipment to monitor and document the ongoing status of the equipment until it is removed. (EC, ON)

(61) Canadian LSBP agencies will continue to seek in-basin destruction capability for low-level PCBs. (EC, ON)

U.S. Actions:

(62) LSBP agencies will encourage owners of transformers and capacitors to test their equipment to identify any remaining PCBs. (EPA, MN, MI)

(63) U.S. LSBP agencies should consider removal of PCB-bearing equipment in lieu of some fines (e.g. Supplemental Environmental Projects). (BR, EPA, MI)

(64) U.S. LSBP agencies will assist in the testing and removal of PCB-bearing equipment, especially for municipalities, schools, hospitals and small businesses. An explanation of the financial consequences of PCB contamination of property should be included in this outreach program. (BR, MN)

(65) U.S. LSBP agencies will ask all the power generators in the basin to endorse the PCB reduction goals outlined in the Stage 2 LaMP and will provide Lake Superior steward awards to facilities that accept the challenge. (EPA, MI)

(66) By the end of calendar year 2000, EPA will formalize the PCB Phasedown Program pilot project with the major utilities in the Great Lakes basin, which is designed to encourage the utilities to phaseout their remaining PCB equipment. (EPA)

(67) By the end of calendar year 2002, EPA will identify federally-owned PCBs in the Lake Superior basin and seek their removal by the departments or agencies that own the PCBs. (EPA)

(2) By the end of calendar year 2006, EPA will work with facilities that have not previously been approached in the Lake Superior basin to establish voluntary agreements or commitments to reduce the use or releases of PCBs. (EPA)

(35) By the end of 2000, EPA will complete the PCB and mercury Clean Sweep pilot project, which includes a component to collect PCB-contaminated oil in the Great Lakes basin, treat the oil to remove PCBs, and recycle PCB-free oil. (EPA)

Future possibility:

(68) Consider PCB identification and collection in other activities. For example, a mercury collection in an industrial facility could also target PCBs, contractor training for mercury-bearing equipment could include PCBs and voluntary agreements could cover mercury, dioxin and PCBs.

4.3.2 Sector-Specific Strategies

While some reduction strategies apply across multiple sectors, others are sector specific. Recommendations for reduction strategies have been developed for the following specific sectors. Facilities within these sectors vary greatly regarding the amount of the nine critical chemicals they use. Thus, the following recommendations are to be considered sector-wide, but may not apply to every facility, equally.

4.3.2.1 Demolition, Salvage and Recycling

Appliances, vehicles and a variety of products that are recycled can contain significant amounts of mercury and PCBs. PCBs are found in ballasts in only the oldest refrigerators. Buildings can also contain mercury and PCBs. Burning scrap materials from buildings, appliances and vehicles can produce dioxin and possibly hexachlorobenzene. For mercury, it is estimated that 4,000 to 20,000 pounds (1,800 to 9,000 kg) of mercury in products is removed from use each year in the state of Minnesota. Based on the Minnesota data, an estimate for the Lake Superior would be approximately 389 to 1,900 pounds (235 to 1,180 kg) of mercury in products per year. A significant portion of discarded mercury-bearing products will pass through the demolition, salvage and recycling sector.

There is a continued need to inform and assist people in the demolition, salvage and recycling sector about PCB and mercury-bearing equipment and how to prevent it from entering the regular solid waste stream. Since the early 1990s, salvage yard operators, appliance recycling operators, and demolition contractors have been becoming more aware of mercury and PCB-bearing equipment. Possible measures of progress towards this strategy could include the quantity of mercury- or PCB-bearing equipment removed from demolished buildings, PCB decommissioning records under TSCA or the Canadian inventory or the number of demolition contractors or salvage yard operators trained in PCB and mercury disposal.

Binational Actions:

(69) LSBP agencies will provide training materials for appliance recyclers and auto salvage operators to assist compliance with applicable rules. (EC, MI, MN)

(70) There are a variety of multiple sector strategies that are also applicable to this sector, including economic incentives, the Lake Superior Steward program and participating in hazardous waste collections. See Section 4.2 for additional strategies.

U.S. Action:

(71) U.S. LSBP agencies will encourage training sessions for demolition contractors. Such training would preferably be associated with licensing requirements or other mandatory procedures. Opportunities to align the training with trade association outreach will be sought. (BR, EPA, MI, MN, WI)

Future Possibility:

(72) Examine successful models (e.g., Great Printers Project) so that critical pollutants can be recovered from salvage and demolition waste streams.

4.3.2.2 Schools

When the twenty-year time-span of the Stage 2 load reduction schedule is considered, it is obvious that Lake Superior basin schools have a critical role. Not only can the school foster a conserver attitude rather than a consumer attitude in its students, but the school campus itself can become a model of the zero discharge philosophy in action. No school in the basin should be incinerating anymore, so their contribution to dioxin production has significantly dropped since 1990. Other sources of the designated chemicals remain and include mercury and PCB-bearing equipment, chemical reagents, solvents and cleaning products. Some schools run their own boilers. Examples of progress in the strategies geared towards schools might be measured by the number of schools enrolling in energy conservation programs, number of students attending environmental learning centers, number of mercury thermometers collected during swaps or the payback periods identified for energy improvements.

Binational Actions:

(73) LSBP agencies will assist schools in seeking out and disposing of mercury and PCBs that are present on school property. (BR, EPA, MI, MN, ON)

(74) There are a variety of multiple sector strategies that are also applicable to this sector, including energy conservation and purchasing policies. See Section 4.2 for additional strategies.

U.S. Action:

(75) By the end of 2000, EPA will develop and distribute through the Binational Toxics Strategy mercury workgroup a package of information related to mercury reduction at schools, including advice on how to eliminate mercury from school laboratories. (EPA)

(76) U.S. LSBP agencies will support basin-wide coordination of citizen and school monitoring programs such as "Lake Superior Lakewatch." LSBP agencies will support continuation of existing programs and formation of new programs based on local interest. These programs will be used as outreach activities for the Binational Program and will increase a sense of stewardship in the Lake Superior basin. (BR, FDL, WI)

(77) Minnesota will investigate the potential use of a mercury-sniffing dog to identify mercury in schools as part of this effort. (MN)

(78) Encourage schools in the Lake Superior basin to commit to green school programs including Energy Star, Blueprint for a Green Campus program and others. (RC)

Canadian Action:

(79) Assist school districts, education agencies, and youth organizations to supplement existing curricula and develop new curricula that are aimed at reducing the nine designated chemicals. This assistance may include training, providing teaching devices, or other necessary activities. (EC)

Future possibilities:

(80) Encourage “Sister school” and “twinning” environmental projects between schools in the basin and with green schools that are outside the basin.

(81) In cooperation with the Lake Superior Binational Forum, a category of the proposed Lake Superior steward program could be developed for schools. Possible activities include developing a curriculum on toxic chemicals, adopting a nearby water-body or certification from the appropriate agency that the school is PCB- and mercury-free.

(82) Encourage Universities to adopt “Zero Discharge Campus” programs.

(83) Establish a Michigan Energy Bank to do energy audits and improve state buildings, including schools.

(84) Encourage pollution prevention projects such as the mercury thermometer swap at Marshall School in Duluth.

(85) Develop a computerized, interactive program that demonstrates how to “prune the use trees.” (“Use trees” are a graphic representation of the myriad ways in which the target chemicals are used and formed. They appear in the Stage 2 LaMP.)

4.3.2.3 Small Business

Small businesses are sometimes not regarded as a significant source of hazardous waste. However, a study on northeastern Minnesota small business found that this sector was responsible for roughly a quarter of the area’s hazardous waste. Small businesses are an important part of the hazardous waste stream and a special effort is needed to educate them to recognize and properly dispose of hazardous waste, including mercury and PCB-bearing equipment, pesticides and solvents. Small businesses in the Lake Superior basin can face higher per unit costs for hazardous waste transportation and disposal because of their small quantities generated and distances involved. In some parts of the basin small business waste collection programs have been established. Two examples are the Western Lake Superior Sanitary District’s Clean Shop program in Duluth and the Northwest Wisconsin Regional Planning Commission very small quantity generator collection program. Recent expansions of the Clean Shop program include mobile collections in northeastern Minnesota and “coupons” to defray the cost to customers. Possible measures of progress would be the number of businesses who participate small businesses collection programs, the quantity of the nine designated chemicals that are collected at sites that are geared towards small business, or the number of inquiries made to such collection sites.

Binational Action:

(86) There are a variety of multiple sector strategies that are also applicable to this sector, including energy conservation, economic incentives, the Lake Superior Steward award and purchasing policies. See Section 4.2 for additional strategies.

U.S. Actions:

(87) By the end of 2000, EPA will publicize, including through posting on its web site, information on how owners and operators of motor vehicle waste disposal wells can comply with the revisions to the Underground Injection Control Regulations that become effective on April 5, 2000. This information will assist these small businesses located in the Lake Superior basin to reduce or eliminate discharges that may adversely impact area ground water that may ultimately flow into the lake. (EPA)

(33) U.S. LSBP agencies will assist industries and business in the basin to conduct industrial clean sweeps and use economies of scale for collections and shipments of hazardous waste. Examples of successful business collection programs include Western Lake Superior Sanitary District's clean shop program and the Northwest Wisconsin Regional Planning Commission's very small quantity generator collection program. (BR, MI, WI).

(88) U.S. LSBP agencies will pursue funding for community and regional toxic reduction activities and networking between Lake Superior communities. In particular, the toxic reduction committees working in Marquette, Michigan; Superior, Wisconsin; and through the WLSSD in Duluth, MN, should be supported. Innovative and alternative funding should also be pursued for these and expanded efforts in communities throughout the Lake Superior basin. (WI)

Canadian Action:

(89) Canadian LSBP agencies will encourage small businesses through an education program to utilize the permanent hazardous waste depots available to them and coordinate the local Chamber of Commerce or trade associations to run pollution prevention education and training sessions for proper waste management. (EC, ON)

Future Possibilities:

(90) Evaluate the potential for adopting or expanding the U.S. federal universal waste rule in order to simplify collection and disposal of hazardous waste from small businesses.

(91) Encourage and coordinate local household hazardous collection sites to take elemental mercury waste from small businesses in a one-time sweep. These sweeps will also involve an educational component to address additional disposal needs.

4.3.2.4 Mining

Although the mining sector has contributed significant reductions in toxic chemicals since 1990, these reductions have mostly occurred due to mines and processing facilities shutting down in Ontario and Michigan. Through a combination of old, outdated facilities, ore bodies playing out and market forces driving down the value of their products, these facilities were no longer economically viable. Algoma Ore Division iron sintering plant, formerly the largest mercury emitter in Canada, was closed in 1998; Copper Range, the largest mercury emitter in the U.S. portion of the basin, was shut down in 1995. For the remaining mines and processing facilities, new technologies can make lower value ore bodies more economical and other factors can extend (or shorten) the life of a facility.

Remaining mining and ore beneficiation still represent a sizable source on the basin. Estimates of mercury from sources in the basin as compared to the reduction schedules indicate that reductions of mercury from mining emissions are needed in order to meet the schedule (see section 5.2.1). Most of these mercury emissions are from the Minnesota taconite industry, which represents seven facilities. Since some facilities generate their own electricity by burning coal, some portion of the mercury emitted is from the coal.

Concerning PCBs, both the U.S. and Canadian PCB data bases indicate that the majority of the PCB equipment still in use in the basin is found in industry and certainly mining is a significant portion of the basin's industrial sector. A 1997 survey of electrical equipment owners in the Minnesota portion of the basin found PCB transformers still in use at Minnesota taconite mines. However, these mines have made progress since 1990 in decommissioning PCB-bearing equipment. PCB-bearing equipment is also being decommissioned as part of the closure plan at the Copper Range mine in Michigan.

For dioxin, the closure of the Algoma Ore Division iron sintering plant in 1998 brought about a significant reduction in dioxin emissions. However, the technologies used at the remaining U.S. and Canadian mines and processing facilities are not known to release dioxin.

Possible measures of progress in tracking reductions from these facilities would include stack testing, amount of PCB equipment removed and tons of ore processed combined with an emission factor.

Binational Action:

(92) There are a variety of multiple sector strategies that are applicable to the mining industry. Energy conservation is especially appropriate given the industry's large demand for power (e.g., an energy audit has benefited at least one of the Minnesota taconite mines). Other strategies that are especially applicable are purchasing policies, incentives and collections.

U.S. Actions:

(93) The Minnesota PCA will identify facilities that use wet scrubbers to treat emissions. The quantity of mercury removed by the scrubber will be estimated and the fate of the scrubber

mercury will be investigated. Possible control technologies such as closed loop systems, hot lime precipitation, and others will also be investigated. (MN)

(94) The Minnesota PCA will assist the taconite and electric utility industries in finding mercury reduction control technologies. The concentrations of mercury in stack gases from the two sectors is similar enough that the same control technology might be used for both. Assistance may or may not take the form of funding. (MN)

(95) U.S. LSBP agencies will assist facilities that produce their own electricity from coal burning to convert to alternative sources such as natural gas turbines. (MN)

(96) U.S. LSBP agencies will support experiments to separate the mercury-bearing pyrite fraction from coal used in their boilers and stabilization of the resulting byproduct. (MN)

Future possibilities:

(97) Encourage facilities to accelerate their destruction program for PCBs. The Canadian Environmental Protection Act gives consideration to the legislative phase out of in-use PCB equipment.

(98) Create a better reporting system for PCBs in U.S. mining operations.

(99) Investigate the fate of mercury during the beneficiation process for the purpose of identifying higher mercury waste streams that could be treated separately.

4.3.2.5 Health Care

The ethics and objectives of the health care sector to do no harm and improve patients health fits well with eliminating the release of highly toxic chemicals to the environment. The health care sector, including clinics, hospitals and dental and veterinary facilities, use mercury in a variety of ways (e.g., instruments, thermometers, lab chemicals, preservatives and dental amalgam). PCBs may also be found in some equipment at facilities with physical plants (i.e., maintenance work shops). Since alternatives exist for many of the mercury-bearing products, this sector has an opportunity to switch to less toxic products. For example, a new state-of-the-art hospital under construction in Thunder Bay is planning not to use mercury-bearing equipment.

The health care sector also releases some toxic substances such as mercury, dioxin and hexachlorobenzene through medical waste incineration. In the Canadian portion of the basin, reductions in dioxin emission from Canadian hospitals have occurred due to hospital and four incinerator closures. A long term problem is the shipping of frozen hospital wastes out of the basin presumably for incineration elsewhere. Currently the two remaining hospitals are looking at alternatives to the incineration of their medical wastes. On the U.S. side, the medical waste incinerators in the basin have been shut down and their waste is shipped to facilities outside the basin.

Measures of progress could include the amount of mercury and PCB-bearing equipment decommissioned, the amount of mercury lab chemicals avoided through purchase of alternative products, the amount of waste dental amalgam diverted from the wastewater stream as well as other changes in the purchasing and disposal methods.

Binational Actions:

(100) LSBP agencies will encourage pollution prevention projects at hospitals, clinics, and medical, dental, and veterinary offices with an emphasis on removing mercury and making the offices “mercury free”. (BR, EC, EPA, KBIC, MN, MI, ON, WI,)

(101) LSBP agencies will support partnerships with dental associations to develop training materials and programs for dental offices regarding the proper handling, collection, and disposal of amalgam wastes. (BR, EC, MI, MN, ON, WI)

(102) There are a variety of multiple sector strategies that are also applicable to this sector, including voluntary reduction agreements, energy conservation, economic incentives, the Lake Superior Steward award and purchasing policies. See Section 2.1 for additional strategies.

(103) LSBP agencies will support and promote implementation of voluntary agreements with the health care industry to reduce use of mercury and formation of dioxin. (BR, EC, EPA, MI, ON, WI)

U.S. Actions:

(104) EPA will continue to contribute resources and expertise to the agency’s voluntary agreement with the American Hospital Association (AHA). Under the terms of this agreement, EPA will assist AHA in meeting its goals of virtual elimination of mercury from hospitals by 2005, and a reduction in total solid waste by 33 percent in 2005 and by 50 percent in 2010. EPA will help AHA to disseminate the guidance manuals on mercury and solid waste reduction for this effort by contributing resources to a series of at least six national workshops that will be held by the end of 2001, as well as making all materials available via the Internet. (EPA)

(105) U.S. LSBP agencies will institute a mercury thermometer swap program where mercury thermometers are exchanged for non-mercury-bearing ones. (FDL, GP)

(106) Urge hospitals to discontinue the practice of sending mercury thermometers home with new mothers and instead use non-mercury thermometers and distribute information on the hazards of mercury in home and the actions that families can take to limit their exposure. The agencies will assist in the preparation of these materials. (RC)

Canadian Actions:

(107) Canadian LSBP agencies will follow up on the 1999 City of Toronto pilot among Environment Canada, suppliers and the Ontario Dental Association and apply the results to the Thunder Bay area. (EC, ON)

(108) Ontario will investigate a regulatory exemption to dispose of mercury wastes reclaimed from dental offices. (ON)

Future possibilities:

(109) Work with the health care sector to properly identify and dispose of batteries, fluorescent lamps, thermometers, pressure testing equipment, dental amalgam collection and recovery, preservatives and laboratory chemicals.

(110) Evaluate lowering medical waste incinerator mercury limits.

(111) Support implementation of the American Hospital Association memorandum of understanding which includes three voluntary goals: 1) virtual elimination of mercury containing waste from the health care waste stream by 2005, 2) plan to reduce total volume of all wastes generated by hospitals by 33 percent by 2005 and 3) establishment of a stakeholders council.

(112) Establish an incentive program for Ontario dentists that encourage them to switch to using non-mercury containing materials.

(113) Work with hospitals to reduce and eliminate the use of PVC products. This will reduce dioxin emissions from the incineration of hospital waste.

4.3.2.6 Energy Production

Fuel combustion, particularly coal combustion, releases new mercury and dioxin into the atmosphere. Fuel combustion is estimated as the second largest source of mercury emissions within the Lake Superior basin, but it is a relatively small source of dioxin. A variety of facilities burn fuel, including electrical utilities (e.g., Ontario Hydro and Northern States Power), industrial utilities (e.g., power plants at taconite mills and burning Kraft liquors at pulp and paper mills) and municipal utilities (e.g., municipal steam plant in Virginia, Minnesota).

PCBs were used in electrical equipment such as transformers and capacitors. According to the 1998 EPA data base, there are 57 transformers owned by utilities in the U.S. portion of the basin that contain high levels of PCBs or that have not been tested. Other inventories show that large numbers of high PCB capacitors are still in use by utilities.

Currently there is no commercially available control equipment that has demonstrated the ability to substantially reduce mercury emissions from coal-fired plants. Several on-going efforts address the issue of mercury from energy production. These broader efforts have the potential to affect the Lake Superior basin in the long term, particularly the mercury strategies in Minnesota, Michigan, Wisconsin, and Ontario, as well as implementation of the Great Lakes Binational

Toxics Strategy, U.S. federal efforts such as implementation of MACT air standards and recent U.S. requirements for utilities to report the mercury content of the coal they burn, and research and development by the utilities themselves.

Progress towards mercury reductions in this sector can be monitored by measuring mercury emissions, changes in control technology, mercury content in coal, and the amount of energy produced by alternative methods. PCB phase-out strategies in Section 2.2.11 are also applicable to this sector.

Binational Actions:

(114) LSBP agencies will encourage the investigation of alternative energy (e.g. low mercury fuels, natural gas, solar, wind) in the Lake Superior basin and encourage residents to purchase energy produced with lower polluting technologies. (BR, GP, MN, ON)

(115) There are a variety of multiple sector strategies that are also applicable to this sector, including voluntary agreements, economic incentives, the Lake Superior Steward award, purchasing policies and PCB phase-out. See Section 4.2 for additional strategies.

U.S. Actions:

(66) By the end of calendar year 2000, EPA will formalize the PCB Phasedown Program pilot project with the major utilities in the Great Lakes basin, which is designed to encourage the utilities to phaseout their remaining PCB equipment. (EPA)

(116) By December 2000, EPA will make a determination about whether to regulate mercury emissions from electric utilities. (EPA)

(117) The U.S. EPA has committed approximately $6 million in FY2000 and FY2001 funds to support mercury research in a number of priority areas including transport, transformation and fate; and human health and wildlife effects of methyl mercury. These research activities are aimed at reducing the uncertainties currently limiting the Agency's ability to assess and manage mercury and methylmercury risks. One particular target of research will be collection and analysis of information on mercury emissions and control options for coal-fired utilities in order to support OAR's mandate for a regulatory determination on mercury controls for utilities by December 15, 2000. (EPA)

(118) By the end of 2000, EPA will provide funding to support workshops in at least one Lake Superior basin state on how to reduce the use of mercury-containing devices at electric utilities. (EPA)

(65) U.S. LSBP agencies will ask all the power generators in the basin to endorse the PCB reduction goals outlined in the Stage 2 LaMP and will provide Lake Superior steward awards to facilities that accept the challenge. (EPA, MI)

(94) The Minnesota PCA will assist the taconite and electric utility industries in finding mercury reduction technologies. The concentrations of mercury in stack gases from the two sectors is

similar enough that the same control technology might be used for both. Assistance may or may not take the form of funding. (MN)

(119) U.S. LSBP agencies will assist utilities in converting from coal-burning technology, which releases mercury, to renewable source energy or natural gas technology to produce electricity (MN).

(120) Promote the long-term goal of having energy utilities convert from coal burning to a natural gas energy source. In the medium-term, householders need to develop an energy conservation ethic that would extend to the purchase of clean fuel. (RC)

Future possibilities:

(121) Encourage utilities to conduct special promotions of their energy conservation programs within the Lake Superior basin. Examples of activities in this effort could include home and industry energy audits, sending mercury awareness and energy conservation information to consumers along with monthly utility bills and offers of assistance to customers in PCB decommissioning.

(122) Hold an energy production workshop for public and industrial utilities and LSBP agencies to seek common ground, provide mentors and partners for small facilities and develop mercury reduction recommendations for this sector.

(123) Canadian LSBP agencies will communicate the long-term goal for energy utilities is to convert from coal burning to a natural gas energy source. In the medium-term, communicate an energy conservation ethic to households that would extend to the purchase of clean fuel.

4.3.2.7 Forest Products

The sub-sectors of the forest products industry considered here are pulp and paper mills, sawmills and wood treatment facilities. Dioxins are released from chlorine-based bleaching processes associated with some pulp and paper mills in the basin. Pulp and paper mills and sawmills can emit dioxins when burning waste wood. Pentachlorophenol (PCP), which contains dioxins, is used in wood treatment facilities (i.e., Northern Wood Preservers site in Thunder Bay). PCP has the potential to leach into soil. In addition, there are sites in the basin where wood preserving was conducted historically which now have soils contaminated with PCP. Significant load reductions of the nine critical pollutants have occurred in this industry. In the past, the Canadian pulp and paper industry produced chlorine on-site using the mercury cell chlor-alkali process that released mercury into the environment. In the 1970s, the Canadian chlor-alkali industry was regulated and mercury cells plants were shut down. While U.S. legislation does not prohibit mercury cell chlor-alkali processes, there are no chlor-alkali facilities operating in the U.S. side of the basin.

Dioxins and furans were also associated with the pulp and paper industry. In response to Canadian regulations in the 1990s on the releases of dioxins and furans from effluents, all mills have a capacity for 100 percent chlorine dioxide substitution and are functioning at near capacity.

This process virtually eliminates dioxins and furans. All the US mills in the basin either use chlorine dioxide or do not use any chlorine in their bleaching process.

Sawmills have reduced emissions through equipment changes allowing for the sale rather than incineration of wood chips, therefore, avoiding the release of dioxins and HCB. The Northern Wood Preservers facility has prevented the release of additional PCP through structural changes and through a clean-up program to collect, confine and eventually treat contaminants.

As part of the recommendations made to the Canadian Ministers of Environment and Health under the Strategic Options Process (SOP), existing wood treating facilities will be assessed against recommended good practices for the design and operation of heavy duty wood treatment facilities. Under the SOP recommendations, a wood preservation facility could participate in a voluntary program. Participants in the voluntary program will have their facilities assessed by a third-party auditor in the year 2000 and will submit implementation plans by June 2001. A facility that does not participate in the voluntary program will be mandated under federal legislation to complete an assessment and submit an implementation plan by the end of the year 2002 using an approved third party auditor. Annual progress reports will be submitted by all facilities and follow-up assessments conducted to track progress in meeting the technical recommendations.

Binational Action:

(124) There are a variety of multiple sector strategies that are also applicable to this sector, including purchasing policies and energy conservation. See Section 4.2 for additional strategies.

Canadian Actions:

(3) Canadian LSBP agencies will continue discussions with the seven pulp and paper facilities: to address purchasing policies to eliminate the nine critical pollutants; to review energy reduction practices thereby reducing dependence on purchased energy that is generated from coal burning facilities which release mercury and dioxin; introduce water conservation to reduce energy use; recycle fluorescent tubes. (EC, ON)

(125) Through voluntary agreements, remove PCBs in storage so that pulp and paper mills are PCB free. (EC, ON)

(126) Pursue clean up of mercury-contaminated sediments in Peninsula Harbour through a partnership among public and private sector organizations. (EC, ON)

(127) Reduce dioxin and furan discharges from the pulp bleaching process by reducing AOX to less than 0.8kg/tonne. (ON)

(128) Operational practices and design of existing wood preservation facilities in the basin will be assessed in 2000 by third party auditors and Environment Canada will invite facilities to participate in a voluntary program. (EC)

Future possibilities:

(129) All sectors of this industry require improved combustion technology to reduce the formation of dioxin.

(130) Conduct materials audit and replace equipment containing mercury and PCBs.

(131) Conduct energy audits of sawmills and discourage burning of wood wastes for energy and encourage use of energy efficient wood kilns.

(132) In the long term, cease the use of pentachlorophenol (PCP) in wood preserving.

(133) Encourage facilities that burn chips and waste wood for energy or heat to use the most efficient furnace possible.

(134) Encourage saw mills to use energy efficient drying kilns.

(135) Encourage forest sector facilities to inventory PCB and mercury-bearing equipment and replace it with benign alternatives.

(136) Promote and encourage research into zero discharge technologies in place elsewhere in the world for effluents and emissions.

4.3.2.8 Other Industrial Sectors

The sector specific sections of this chapter address most of the industries operating in the Lake Superior basin that have a sector-specific role in reducing zero discharge pollutants. Although not heavily industrialized, the Lake Superior basin has several other large industrial facilities that are not covered specifically elsewhere in the document. These facilities include ship repair, lime processing, grain elevators, other shipping concerns, an oil refinery, and various manufacturing facilities. Generally, there are few sector-specific strategies applicable to these facilities. This “other industry” section of the document houses strategies applicable to industrial or manufacturing facilities in the Lake Superior basin that are not covered in other sections of the Stage 3 Lakewide Management Plan. Large industrial facilities in particular can contribute to the reduction goals for the zero discharge pollutants through PCB phase-outs, mercury-containing equipment phase-outs, purchasing policies, energy conservation, packaging choices and solid waste management, hazardous waste management, and attention to contaminants in feedstock chemicals. In addition, stormwater from industrial facilities and urbanized areas can serve as a significant source of Lake Superior critical pollutants in the lakewide and local remediation category.

Industrial and manufacturing sectors outside of the Lake Superior basin are addressed in the “Out of Basin Strategies” section of the plan.

Manufacturing:

U.S. Action:

(137) By the end of 2000, EPA will publicize, including through posting on its web site, information on how to develop a mercury reduction plan at a manufacturing plant. This information will include mercury reduction plans developed at three steel mills under a voluntary agreement between the mills, EPA, the Indiana Department of Environment, and the Lake Michigan Forum. (EPA)

Oil Refining:

The oil refining process is recognized as a likely source of mercury emissions that has yet to be quantified. Mercury is found as a contaminant in crude oil. This mercury then may be emitted via air emissions, water discharges, other wastes, or may end up in products. Minnesota estimates that more than 50 lbs. of mercury per year enter its two refineries (not in the Lake Superior basin) via crude oil. Murphy Oil USA's Superior, Wisconsin refinery is the only oil refinery within the Lake Superior basin.

U.S. Action

(138) WDNR will work with the region's oil refining industry to evaluate use, generation, and environmental release of Lake Superior critical pollutants, and investigation options for pollution prevention and control. (WI)

Binational Action:

(139) There are a number of multiple sector strategies particularly applicable to large industrial facilities including PCB phase-outs, PCB mentoring with smaller facilities, mercury equipment replacement, purchasing policies, energy conservation, participation in regional pollution prevention initiatives, attention to chemical feedstock contamination, solid and hazardous waste management.

Future possibility:

(140) Continue to work with industrial facilities on stormwater management and best management practices for storage piles.

4.3.2.9 Public Sector

The public sector can take several types of action to reduce loads of pollutants to the Lake Superior basin. Federal, state, and provincial regulatory agencies can encourage pollution prevention, mandate special protection for the basin and promulgate new rules to minimize or eliminate pollutant loads. In addition, the public sector has many of the same opportunities as the private sector to participate in energy conservation programs as well as adopting environmentally friendly purchasing policies. Many of the important pollution prevention strategies applicable to the public sector are listed in the energy conservation, communities and households, and solid waste management sections.

Universities and schools can serve an important role in developing curricula and municipalities can implement action at a local level more efficiently than other levels of government.

Municipalities and other local units of government have responsibilities and functions (i.e., solid waste management) that can influence pollutant load reductions.

The measures of progress will be as varied as the range of potential actions and could include indirect measures such as the number of U.S. communities adopting burn barrel ordinances as well as direct measures of mercury loads reduced through local or regional reduction strategies.

Pollution Prevention

Most of the pollution prevention actions are covered in other sections of this chapter. This section lists actions not addressed elsewhere.

Canadian Action:

(141) Canadian LSBP agencies will expand the Pollution Prevention Demonstration Site Program to both Canadian Federal facilities and First Nations in the Lake Superior drainage basin. The program addresses generation of hazardous wastes through such activities as identification and demonstration of alternative products, practices, and technologies. (EC)

Future possibilities:

(142) Canadian LSBP agencies will link company websites to Lake Superior websites in order to publicize and promote positive actions.

(143) Sustain and expand pollution prevention technical assistance programs for facilities in the Lake Superior basin. Programs include the Retired Engineer Training and Assistance Program (RETAP), Minnesota Small Quantity Generator Program, Wisconsin's SHWEC technical assistance program. LSBP agencies will use these programs to work with trade associations and individual facilities in the basin to identify opportunities to reduce use, generation, storage, and release of Hg and PCBs and other persistent toxic substances (e.g. toxic reduction plans, voluntary audits).

Control and Regulation

There are significant differences in the regulatory regimes of the U.S. and Canada. Generally regulatory measures are not specific to the Lake Superior basin. Many regulatory measures that could be used by state, provincial, or federal governments to reduce pollutant loads to Lake Superior would apply across the jurisdiction enacting them. Many regulatory actions, particularly those addressing air emissions are addressed in Section 4.3.3, Out of Basin strategies. Actions involving clean up of contaminated sites are addressed in Section 4.4.

Binational Action:

(144) LSBP agencies will coordinate LaMP critical pollutant reduction strategies with Total Maximum Daily Load Reductions or limits under Ontario's Certificate of Approval process. (FDL, MN, ON)

U.S. Actions:

(116) By December 2000, EPA will make a determination about whether to regulate mercury emissions from electric utilities. (EPA)

(145) EPA will provide technical and regulatory assistance to Lake Superior basin States, Tribes and local governments on how to identify and address Class V wells that may endanger ground water within the Lake Superior basin and therefore pose a contamination threat to the waters of Lake Superior. (EPA)

(146) EPA will provide priority review to potentially endangering and high priority Class V well types identified within delineated source water protection areas for Lake Superior public drinking water system intakes in Michigan and Minnesota. (EPA)

(147) U.S. LSBP agencies will pursue bans on non-essential uses of the nine persistent, bioaccumulative, toxic substances targeted for zero discharge (e.g. light switches in running shoes). (BR, MI, MN)

(148) For toxic pollutants with effluent limitations that are below reliable levels of analytical detection (e.g. nine zero discharge pollutants), U.S. LSBP agencies will require toxic reduction plans in each new or reissued NPDES permit for point sources discharges to the basin. U.S. LSBP agencies will require toxic reduction plans in new or reissued air permits for facilities that could reasonably be expected to emit any of the nine zero discharge pollutants based on knowledge of the process. (BR, MI)

(149) The states and U.S. EPA should include appropriate limits for persistent bioaccumulative toxic substances in air emission permits to eliminate or further reduce the deposition of these substances in the Lake Superior basin. Also, lower emission rates should be used to define major source applicability for MACT standards. (MI, MN)

(150) States and U.S. EPA will include pollution prevention components in enforcement settlements as appropriate. (MI)

(151) U.S. LSBP agencies will work with individual facilities in the basin to identify opportunities to reduce storage, use, or release of mercury and PCBs (e.g., toxic reduction plans, voluntary audits, “check lists” to be included in the permit applications). (EPA, MI)

Canadian Action:

(152) Ontario will actively pursue the development of regulations to require monitoring and reporting air emissions, of public concern, from significant industrial and commercial emission sources. (ON)

Future possibilities:

(153) Require new industrial facilities to demonstrate they will not release dioxin, HCB or OCS.

(12) Acknowledge credit for beyond-compliance reductions, in order to provide an incentive for basin facilities to voluntarily reduce the use and emissions of the nine critical pollutants. The purpose of these credits is to avoid penalizing facilities that have already achieved reductions before nation-wide reduction programs are established.

(154) Encourage local units of governments to pass ordinances banning burn barrels.

(155) The State of Minnesota will evaluate its burn barrel law and revise if necessary.

<u>Special Designation</u>

The 1991 agreement establishing the Lake Superior Binational Program included the following three actions in the U.S. action plan.

- Initiate appropriate state procedures to designate all waters of the Lake Superior basin as Outstanding International Resource Waters.

- Initiate appropriate state procedures to designate certain areas of the Lake Superior basin as Outstanding National Resource Waters.

- Evaluate the possibility of pursuing and/or supporting other special designations of areas in the Lake Superior basin.

The first action item has been completed by the states of Michigan and Minnesota, which have adopted an Outstanding International Resource Water (OIRW) designation for Lake Superior. The effect of this designation is to prohibit new or increased water discharges of the nine zero discharge pollutants unless best technology in process and treatment is employed. In 1996, Wisconsin initiated rulemaking procedures for the OIRW designation and invited public comment on other possible designations, including an Outstanding National Resource Water (ONRW) designation that would prohibit discharge of an expanded list of pollutants to Lake Superior. Due to polarized public opinion, special designation rulemaking in Wisconsin was suspended in 1997. Currently the special designation issue is being explored in Wisconsin by a public advisory group established by WDNR.

The second action item from the 1991 Binational Program is an Outstanding National Resource Water (ONRW) designation with the purpose of prohibiting new or increased point source discharges of the nine target chemicals in certain areas such as national and state parks and refuges. The ONRW designation for certain areas within the basin has not been pursued, however designations with equivalent results have been implemented. In 1984, Minnesota adopted a special designation that prohibits new or expanded discharges in certain waters in the basin. A portion of the Lake Superior shoreline was included in this designation in 1998 as part of an agreement with the Grand Portage Band of Lake Superior Chippewa. In 1989, Wisconsin designated certain tributaries to Lake Superior such that discharges would not be allowed to lower background water quality. Michigan adopted an Outstanding State Resource Water (OSRW) designation in 1997. The OSRW designation prohibits the lowering of water quality in certain waters of the basin.

Tribes with reservations in the basin have used special tribal designations to protect those waters. The Grant Portage tribe, the Fond du Lac tribe, the Keweenaw Bay Indian Community and the Red Cliff tribe have designated certain reservation waters Outstanding Reservation Resource Waters. This designation prohibits discharges of certain bioaccumulative chemicals.

Some tribes in the U.S. have also supported an ONRW designation for Lake Superior. The Great Lakes Indian Fish and Wildlife Commission, an organization representing the off-reservation interests of eleven tribes with harvesting rights in Lake Superior and portions of the basin, has passed a resolution strongly urging a federal ONRW designation for Lake Superior. In addition, the Red Cliff tribe has expressed its support for an ONRW designation for Lake Superior.

The following actions are carried forward from the 1991 Binational Program Agreement into the LaMP Stage 3.

U.S. Action:

(156) Minnesota will consider the applicability of the Outstanding Natural Resource Water (ONRW) designation in future reviews of water quality rules. (MN)

Canadian Actions:

(157) Canada and Ontario will evaluate the possibility of pursuing a special designation for the waters of Lakes Superior and Nipigon. (EC, ON)

(158) Ontario will provide special designations, including protected areas, under the Ontario Living Legacy Program for a significant portion of the Canadian Lake Superior shoreline. (ON)

(159) Canada and Ontario agree to undertake the necessary requirements to establish a National Marine Conservation Area in the Lake Superior basin. (EC, ON)

Future possibilities:

(160) Evaluate the possibility of pursuing and/or supporting other special designations (regulatory or non-regulatory) in the Lake Superior basin in the future.

(161) Tribes may consider additional special designations in the future.

4.3.2.10 Communities and Households

Actions by individuals influence release of the nine critical chemicals to the environment. For instance, many products found in households and used throughout communities contain mercury. Because of the many potential sources, education and outreach to individuals is an important activity for the zero discharge demonstration program. Community and household pollution prevention may address most of the nine zero discharge chemicals. However, mercury is a prime chemical of concern. Because communities and local units of government have responsibilities for the management of wastewater and solid waste, they are an important audience for pollution prevention education and technical assistance.

Communities also have been effective leaders and mentors in pollution prevention. Since 1990, several communities in the Lake Superior basin have undertaken community-based toxic reduction projects. In the U.S., federal funding was provided to the Western Lake Superior Sanitary District (WLSSD) to develop a document titled “Blueprint for Zero Discharge”, which is a guide for wastewater treatment plants in conducting pollution prevention to reduce discharge of the zero discharge chemicals. The WLSSD has been able to lower its mercury discharge significantly, as a result of pollution prevention they have conducted in their community. The WLSSD has served as a mentor for other communities in the basin. The Wisconsin Mercury Sourcebook is another guide that was developed to help communities implement source reduction. Marquette, Michigan and Superior, Wisconsin both have active community-based toxic reduction committees with a strong focus on outreach and education. In all of these efforts, staff at the municipal wastewater treatment plants have been key to the effort’s success. In many respects, communities can be much more effective than government agencies with pollution prevention and outreach to households, business, and industry.

In Canada, the community group Thunder Bay 2002 with the support of the provincial government has established a button battery recycling program in Thunder Bay and Sault Ste. Marie. Button batteries are found in watches and other small electronic equipment. Each battery can contain as much as 2.5 grams of mercury. The initiative demonstrated that significant quantities of mercury can be removed from the waste stream by using colorful collection depots placed on the counters of major retailers. The button battery recovery project has also been a very effective means of raising public awareness around Lake Superior about the problem of mercury contamination.

Solid waste management is also another area where actions by households and communities influence release of the zero discharge chemicals. (See Section 4.3.1.9, Solid Waste Management).

Quantifying the amount of pollutants reduced through implementing a community toxics reduction program is expensive. In the case of the WLSSD Blueprint for Zero Discharge project, a substantial budget provided for detailed mercury sampling in the collection system. This enabled documentation of the reduced mercury discharge as a result of implementing the p2 program. Similar documentation in all communities implementing toxic reduction activities would not be cost effective. A measure of progress could be the number of communities participating in similar “zero discharge” toxic reduction programs.

Binational Actions:

(162) LSBP agencies will work with communities to provide sector-specific pollution prevention outreach such as workshops for the medical and dental communities, and other important sectors. (BR, EC, EPA, MI, WI)

U.S. Actions:

(88) U.S. LSBP agencies will pursue funding for community and regional toxic reduction activities and networking between Lake Superior communities. In particular, the toxic reduction committees working in Marquette, Michigan and Superior, Wisconsin, and through the Western Lake Superior Sanitary District (WLSSD) in Duluth, MN, should be supported. Innovative and alternative funding should also be pursued for these and expanded efforts in communities throughout the Lake Superior basin. (WI, BR)

(163) U.S. LSBP agencies will encourage a source separation program to divert household hazardous material such as cleaners, batteries and fluorescent lights from landfills and burn barrels. (KBIC)

(164) EPA has initiated and will continue to work with developing partnerships between the Hearth Products Association and any appropriate parties (i.e. state, tribal, local) towards participation in the wood stove change-out program in the Great Lakes basin. This exchange program allows for the consumer switch from older, less efficient wood-burning stoves to new more combustion efficient stoves that reduce the amount of air toxic emissions. (EPA)

(165) Pursue funding for a public awareness campaign in support of the community toxic reduction activities. The P2 awareness campaign should focus on preventing pollution in the home, conserving energy, using alternative products, encouraging use of clean sweep collections and other proper disposal of household hazardous wastes. Elements of the campaign could include a brochure for owners of old homes on how to dispose of banned and outdated products, and a "Get rid of it" brochure for the "nasty nine" chemicals. Consumer groups will be sought as partners in this strategy. (FDL, RC)

(166) Establish a recognition program for all wastewater treatment plants that implement the Blueprint for Zero Discharge. (RC)

Canadian Actions:

(167) Canadian LSBP agencies will support initiatives to reduce reliance on petroleum hydrocarbons for energy production or space heating purposes at First Nations (use of alternative technologies/green power). (EC)

(168) Canadian LSBP agencies will support First Nations on contaminated site assessment and remediation, (primarily with petroleum hydrocarbon contamination). (EC)

Future possibilities:

(169) Encourage municipalities to enforce sewer use by-laws to discourage illegal release of toxic substances into the sewer system. At the same time conduct education programs for householders and small businesses for alternative disposal or pretreatment of wastes.

(170) Encourage retailers in Thunder Bay and Sault Ste. Marie, Ontario (Radio Shack, Wal-Mart, and Japan Camera) to form a partnership with environmental organizations (Thunder Bay 2002 and Clean North of Sault Ste. Marie), the Great Lakes renewal Foundation and other community partners to recycle button batteries.

(171) Encourage Thunder Bay 2002, Clean North of Sault Ste. Marie, and the Great Lakes Renewal Foundation to form a partnership to retrieve and recycle the mercury in fluorescent lamps and thermostats from households, industries, and institutions.

(172) Work with municipalities to improve pretreatment programs to detect and help eliminate trace sources of mercury, PCBs, and pesticides discharging into sewage systems.

(173) Provide technical and financial assistance to municipalities and schools to remove and properly dispose of equipment, materials, and wastes containing mercury and PCBs.

(174) Fund a sewer cleaning demonstration project to remove historic deposits of mercury and pesticides.

(175) Support a PVC awareness campaign with the purpose of reducing PVC consumption in the basin.

(123) Canadian LSBP agencies will communicate the long-term goal for energy utilities is to convert from coal burning to a natural gas energy source. In the medium-term, communicate an energy conservation ethic to households that would extend to the purchase of clean fuel.

Also see Sections 4.3.1.9, Solid Waste Management, and 4.3.1.7, Waste Collections

4.3.3 Out-Of-Basin Strategies

Via the St. Mary's River at Sault Ste. Marie, the Lake Superior basin drains into the other Great Lakes and the St. Lawrence River. The Lake Superior basin is also connected to the rest of the world through the import and export of products and the emissions it generates and receives. While the focus of the Lake Superior Binational Program remains on protecting and restoring the basin, action is needed outside the basin in order to protect it. The primary responsibility for out-of-basin reductions will depend on actions taken by the federal governments. State or provincial-wide programs can also affect pollutant reductions important for Lake Superior. States can also support U.S. federal agencies to affect changes in federal programs. In addition, tools such as emission inventories and monitoring programs are important components of government agency efforts to reduce emissions of toxic pollutants to Lake Superior.

4.3.3.1 Atmospheric Deposition

The primary route by which the nine designated chemicals enter the Lake Superior basin is from atmospheric deposition. Mercury, dioxins and furans, PCBs, pesticides and other chemicals are released into the atmosphere from sources both within and outside the basin. The Zero Discharge Demonstration Project will continue to focus on sources within the basin. However, the following broader efforts are important for meeting the Lake Superior goals. The challenges to U.S. and Canadian agencies by the Great Lakes Binational Toxics Strategy is in Addendum 4-B.

Binational Actions:

(176) The Great Lakes Binational Toxics Strategy should be pursued to meet the short-term, interim goals of the Lake Superior Binational Program for mercury, PCBs, dioxin, hexachlorobenzene, octachlorostyrene, and pesticides. (EC, EPA, MI, MN)

(177) The federal governments should ensure the protection of Lake Superior during negotiations and implementation of international agreements and protocols (e.g., ECE, UN POPs, NARAPs, NAFTA).

U.S. Actions:

(178) EPA will promulgate regulations requiring emission limits on pollutants (such as mercury and dioxin) for all operating medical waste incinerators by the end of 2000. All medical waste incinerators that are not equipped to meet these requirements will be required to shut down by the end of 2001. (EPA)

(179) The U.S. federal government should evaluate lowering the nationwide limits on sewage sludge and medical waste incinerators, especially for mercury. (MN)

(180) The U.S. EPA should close the RCRA Subtitle C loop that allows the incineration of mercury-bearing hazardous waste. (MN)

(181) Wisconsin DNR will continue to pursue a statewide mercury reduction strategy including proposed legislation providing for cap and trade of mercury emissions in the state. (WI)

(182) U.S. LSBP agencies will work on a cooperative basis to establish a national ambient air toxics monitoring network. This network can be used to determine atmospheric deposition of toxics and assess multi-pathway exposures to air emissions such as the bioaccumulation of methylmercury in fish resulting in exposures to people who eat fish. (WI)

(183) U.S. LSBP agencies will continue to participate in the Great Lakes Regional Air Toxics Emissions inventory to compile a database of point, area and mobile source emissions for the Great Lakes region. (WI)

(184) U.S. LSBP agencies will work with operators of medical waste incinerators to pursue reductions of mercury, dioxin and hexachlorobenzene through source reduction elimination/segregation, including the removal of noninfectious waste from the incinerator waste stream. (BR)

Future Possibilities:

(12) Acknowledge credit for beyond-compliance reductions, in order to provide an incentive for basin facilities to voluntarily reduce the use and emissions of the nine critical pollutants. The purpose of these credits is to avoid penalizing facilities that have already achieved reductions before nation-wide reduction programs are established.

(185) The LSBP agencies support the U.S. EPA and STAPPA – ALAPCO (State and Territorial Air Pollution Program Administrators - Association of Local Air Pollution Control Officials) in developing a nationwide program to reduce and eventually eliminate backyard burning.

(186) Consider dioxin releases from the transportation sector.

(53) Encourage a nationwide ban on small incinerators.

4.3.3.2 Manufacturing

The Lake Superior basin is not self-sufficient and its residents must purchase products manufactured outside the basin. Products that contain or generate any of the nine designated chemicals are of concern because the manufacturing of these products may release these contaminants into the air. The product itself may contain these chemicals when it is brought into or disposed of in the basin. While the Zero Discharge Demonstration Project will continue to focus on sources within the basin, the following broader actions would support the Lake Superior goals.

Binational Action:

(187) LSBP agencies will support federal initiatives to lower the reporting limits on persistent, bioaccumulative toxic chemicals under the TRI (US) and the NPRI (Canadian) and lower the reporting limit for PCBs under TSCA (US) even further in order to track low level waste. (BR, EC, EPA, MN)

U.S. Actions:

(188) Foster nationwide product stewardship and reverse distribution systems with manufacturers. (MN)

(19) U.S. LSBP agencies will encourage a nationwide dialogue on the import of mercury-bearing products. Nationwide labeling of mercury products will also be encouraged. (EPA, MN, MI)

(189) Support federal and state initiatives to provide incentives to the utility industry to develop mercury control technology and to invest in alternative energy sources. (MN)

(190) The U.S. federal government should tighten the reporting requirements on export shipments of pesticides, especially pesticides that are no longer used in the United States. (MN)

(191) The U.S. federal government should consider a plan to permanently retire its mercury stockpile and to retire other sources of elemental mercury instead of recycling. (EPA, MI, MN)

Future possibilities:

(192) Follow the example of the Canadian government by accelerating the decommissioning of the remaining US mercury cell chlor-alkali plants.

(193) Increase dialogue with industries and manufacturers who import mercury-bearing products or products contaminated by dioxin or HCB.

(53) Encourage a nationwide ban on small incinerators.

4.4 CONTAMINATED SITES STRATEGIES

Although Lake Superior is the most pristine of the Great Lakes, the Lake Superior basin has a history of resource extraction and heavy industry. The legacy of the region's industrial history remains in areas of contaminated soils and sediments. Although the extent and magnitude of sediment contamination in Lake Superior is much less than in the other Great Lakes, Lake Superior has eight Areas of Concern (AOC) where Remedial Action Plans are underway. There are also other localized areas of contaminated sediment and soils. Decisions concerning evaluation and management of contaminated sites or sediments usually occur at a local, state, or provincial levels. However, the LaMP can serve to integrate these activities toward common lake-wide goals where appropriate. Table 4-8 lists and describes several contaminated sites in the Lake Superior basin. The table focuses on areas of contaminated sediment in the basin and lists some upland sites where the nine zero discharge pollutants have been detected or are suspected.

4.4.1 Overview of Lake Superior basin Contamination

Several of the nine zero discharge pollutants have been detected in sediments from the Lake Superior AOCs. Mercury is a contaminant of concern in the St. Louis River (Duluth-Superior Harbor) AOC; Thunder Bay, Jackfish Bay, and Peninsula Harbor in Canada; St. Marys River (Michigan-Ontario), and Deer Lake in Michigan. Mercury contamination in the sediment in these areas is due in part to historical discharges of mercury used as a fungicide or slimicide in industrial applications, use of mercury reagents, and discharge by chlor-alkali plants. In general, mercury contamination is also a result of the varied ubiquitous activities that have made mercury globally distributed in the environment. Dioxins, furans, and PCBs are also among the sediment contaminants found in several Lake Superior AOCs. The extent to which contaminated sediments serve as a source for zero discharge pollutants entering the food chain in the Lake Superior ecosystem has not been determined. Loading of sediment-derived contaminants into Lake Superior from the Duluth-Superior Harbor was examined by the Minnesota Pollution Control Agency (MPCA, 1999). Although the study was based on a small number of samples, the results generally indicate a net flux of dieldrin, DDT metabolites, PCBs and PAHs into Lake Superior. Similar types of loading studies at other Lake Superior AOCs could provide important information to assess the importance of contaminated sediments in harbors and bays to the contaminant picture of the Lake as a whole.

4.4.2 Objectives

Restoration of impaired uses is the goal outlined in the Great Lakes Water Quality Agreement to guide development of RAPs and LaMPs. For the Lake Superior LaMP, the zero discharge demonstration program for nine target pollutants adds an additional goal. Zero discharge is the management goal for the nine target pollutants. The Stage 2 LaMP reduction targets apply to this goal. Virtual elimination from the environment is the "environmental goal" stated in the Stage 2 LaMP for these pollutants. Like zero discharge of sources, virtual elimination from the environment is a conceptual goal.

Although Remedial Action Plans address contaminated sediment cleanup on a local scale, the Lake Superior LaMP puts forward a more aggressive lake-wide goal for sediment contaminated with zero discharge pollutants. In practical terms, the virtual elimination goal for Lake Superior should serve two main purposes. It brings contaminated sediment issues into the scope of the LaMP. It also means that management decisions regarding contaminated sites and sediments should take into account how the site impacts the overall Lake Superior ecosystem rather than taking a purely local view.

Dioxin is one of the nine zero discharge / virtual elimination pollutants that is found at sites contaminated with pentachlorophenol. Pentachlorophenol contaminated soils and sediment were estimated as a Lake Superior basin dioxin source in the Stage 2 LaMP. Pentachlorophenol has 2,3,7,8-TCDD as a potential contaminant, particularly in pre-1971 formulations. The Stage 2 LaMP included estimates of potential dioxin in soils based on pentachlorophenol data from two sites in the basin: Northern Wood Preservers in Thunder Bay, ON and Crawford Creek / Koppers Co. site in Superior, WI. Three other wood preserving sites in Michigan, which have pentachlorophenol contamination, are listed in the Stage 1 LaMP update (1995). Again, the virtual elimination goal for Lake Superior should serve to expand the scope of clean up decisions for any of these sites, beyond local impacts.

4.4.3 Strategies

The nine zero discharge pollutants are the primary focus of this Stage 3 LaMP. However, other critical pollutants are responsible for sediment contamination in many AOCs and other contaminated sites in the Lake Superior basin. These chemical groupings are found in the Stage 2 LaMP. Many of the lake-wide remediation chemicals were listed as critical pollutants for Lake Superior because they contaminate sediments at several sites in the Lake Superior basin. PAHs are a particular case in point. This group of organic chemicals is found at levels that degrade habitat in several nearshore sediment "hot spots" around the basin. The environmental goal for lake-wide remediation pollutants is to remove impairments and restore beneficial uses. In practical terms, the LaMP serves to highlight the cumulative impacts of lake-wide remediation pollutants such as PAHs in the Lake Superior basin.

Local remediation pollutants (listed in the Stage 2 LaMP) are the other group of critical pollutants responsible for sediment contamination in the Lake Superior basin. This group consists of primarily metals that are responsible for localized sediment contamination, addressed through Remedial Action Plans. The role of the LaMP is more limited for this group of pollutants.

General measures of progress regarding contaminated sites include: determining the amount of contaminant removed from the environment through sediment or site remediation; and, assessing the number of contaminated areas undergoing characterization monitoring.

Binational Action:

(194) LSBP agencies will initiate necessary sediment remediation measures at AOCs and other sites known to contribute persistent bioaccumulative toxic substances to the Lake Superior ecosystem. (EC, MN, ON, WI)

(195) The Superfund program is currently working to complete remediation at two sites in the Lake Superior basin. These include Torch Lake in Michigan and the St. Louis River in Minnesota. Superfund commits to completing remedies for these two sites by the end of FY 2005. (EPA)

Canadian Action:

(126) LSBP agencies pursue clean up of mercury contaminated sediments in Peninsula Harbour through a partnership among public and private sector organizations. (EC, ON)

Future possibilities:

(196) LSBP agencies consider cumulative impacts on the Lake Superior basin when making clean up decisions about sites or sediments contaminated with zero discharge or lake-wide remediation pollutants.

(197) LSBP agencies support coordination among Lake Superior RAP committees and other local remediation and monitoring efforts to share information and work toward lake-wide goals.

(198) LSBP agencies develop sediment quality criteria and guidance for use in identifying contaminated sediments.

Table 4-8 Contaminated Sites in the Lake Superior Basin

Location / Description	Sources	Pollutants	Status
St. Louis River AOC (MN-WI) 13,000 acre estuary and upstream areas in watershed. Sediment contamination in hot spots. Some diffuse contamination	Historical discharges: steel mill, coal gasification, wood preserving, coal and oil shipment, oil refining, shipbuilding, pulp and paper, tar and chemical, POTWs.	Mercury, PAHs, diesel range organics, PCBs, metals, dioxins/furans	Sediment characterization studies of AOC in 1992-1996. Status of hotspots varies.
USX Site (Superfund)	Steel mill operated until 1979	1993 sampling of St. Louis River sediments adjacent to site found PAHs, Mercury, Arsenic, Lead, other Metals, PCBs, Dioxin	Cleanup on land. No sediment clean- up to date.
Interlake / Duluth Tar Site (Superfund)	Coking, tar and chemical plant historical discharges	PAHs, Mercury, other metals in bay sediments	Cleanup on land. Sediment cleanup options under consideration.
Minnesota slip	Boat slip in lower harbor	PAHs, PCBs, Mercury, other Metals, pesticides	Further characterization recommended in 1994 sediment study.
Howards Bay	Shipyard and other possible waterfront activities	Lead, Arsenic, Mercury other metals, PCBs, PAHs, pesticides	On-land cleanup complete. Enforcement action continues.
Newton Creek / Hog Island Inlet	Murphy Oil refinery historical discharge	Diesel range organics, oil and grease, PAHs, lead, chromium, mercury	Murphy Oil refinery 1997 cleanup of 1.4 acres/1600 cubic yards in upstream impoundment. About 18,000 cubic yards contaminated sediment remains downstream.

Table 4-8 Contaminated Sites in the Lake Superior Basin

Location / Description	Sources	Pollutants	Status
Crawford Creek wetland	Wood preserving historical discharge	PAHs, penta-chlorophenol, creosote in soils and sediment in wetland	RCRA Corrective action – characterization studies continue.
WLSSD / Coffee Creek and Miller Creek embayment	Historical and current POTW, urban stormwater	Mercury, PCBs, PAHs, pesticides, heavy metals, dioxins detected in embayment sediments.	Source control. No sediment action under consideration currently.
Wisconsin Point landfill	Former municipal and industrial dump in wetland on L. Superior	Volatile and Semi-volatile Organic Compounds in old landfill.	Clay capped with monitoring wells. Possible net loading to L. Superior.
DM&IR, Proctor (MN) Upland site in St. Louis River AOC	Railyard since 1880s. Landfills, landfarms, repair and fueling facilities.	PCBs, other contaminants.	Activity under RCRA. PCBs up to 50 mg/kg were landspread as part of an old remedy agreement with MPCA.
Kotula Iron and Metal Near Hibbing, MN. Upland site in St. Louis River watershed.	Scrapyard, transformers.	PCBs, metals, semi-volatile organic compounds, PCE	Characterization studies for Superfund.
Ashland waterfront site Ashland, WI: 10 acre contaminated sediment area in Chequamegon Bay, upland and groundwater contamination.	Historical coal gasification plant	PAHs in bay sediments	Cleanup options under consideration.

Table 4-8 Contaminated Sites in the Lake Superior Basin

Location / Description	Sources	Pollutants	Status
Torch Lake AOC (MI) (Superfund site) Includes Keweenaw waterway, Torch Lake, and various upland sites.	200 million tons copper ore tailings deposited 1860s-1960s	Copper, Arsenic, Lead, Chromium, other metals	Superfund 1994 Record of Decision calls for capping and re-vegetation of above-water contaminated areas. The phased project was initiated in 1999 and is expected to be completed in 2004.
Hubbell "hotspot" on western shore of Torch Lake	Smelter site and bulk coal handling	Copper, PAHs	Part of Superfund site
Gay Mill Stamp Sands, 200+ acres deposited in Lake Superior, of unknown depth, extending approximately four miles along the shoreline to the Little Traverse River	Copper ore tailings deposited decades ago	Numerous metals	Not included in the EPA Superfund site. The DEQ-ERD is evaluating whether to request USACoE assistance in evaluation and analysis of alternatives.
Freda/Redridge Stamp Sands, approximately 80 acres deposited in Lake Superior, of unknown depth, approximately 13 miles along the shoreline to the North Entry	Copper ore tailings deposited decades ago	Numerous metals	Not included in the EPA Superfund site. The DEQ-ERD is evaluating whether to request USACoE assistance in evaluation and analysis of alternatives.
Assinins Stamp Sands, approximately 30 acres deposited in Lake Superior, of unknown depth, approximately 2 miles along the shoreline to near Sand Point	Copper ore tailings deposited decades ago	Numerous metals	Not included in the EPA Superfund site. The DEQ-ERD is evaluating whether to request USACoE assistance in evaluation and analysis of alternatives.
Deer Lake AOC (MI) 906 acre impoundment of Carp River	Historic mine lab discharge of Hg reagents to WWTP	Mercury	Source addressed in 1981.

Table 4-8 Contaminated Sites in the Lake Superior Basin

Location / Description	Sources	Pollutants	Status
MI wood preserving sites Sites of 3 wood preserving plants in watershed: Wakefield, Munising, Newberry		Penta-chlorophenol	*Listed in Stage 1 LaMP update.*
St. Mary's River AOC (ON-MI)	Steel mill, paper mill, historic discharge from tannery, WWTPs	Mercury, Heavy metals, PAHs, oil-grease, PCBs	Status of contaminated sites varies. Source control improvements in 1990s. However, an overall contaminated sediment management plan, including delineation and mapping, is needed.
Algoma slip	Steel mill-coking	PAHs	20,000 cubic yards contaminated sediment removed; unknown amount remaining.
Cannelton Industries (Superfund site)	Historical tannery	Chromium, Mercury	Remediation work completed summer 1999. Contaminated sediments remain Tannery Bay. Site monitoring will be carried out on an ongoing basis.
Peninsula Harbor AOC (ON)	Pulp mill and chlor-alkali plant historic discharge.	Mercury, PCBs, oil-grease, heavy metals	Pulp mill waste treatment upgrade to full secondary treatment. RAP/PAC recommends removal and confinement of highest mercury contaminated sediments, natural recovery for lesser contaminated areas.
Jackfish Bay AOC (ON) Includes 14 km of Blackbird Creek from mill discharge to Jackfish Bay.	Pulp / paper mill discharge	Resin, fatty acids, tetrachloro-dibenzofurans, PCBs, HCB, phenolic compounds, Cadmium, Zinc	Full secondary treatment of all effluent installed- mill has capability to operate at 100 percent chlorine dioxide bleaching, decreasing AOX discharge.

Table 4-8 Contaminated Sites in the Lake Superior Basin

Location / Description	Sources	Pollutants	Status
Moberly Bay (Lake Superior)	Receiver for mill effluent	Same as above	Secondary treatment has resulted in improvements in sediment and biota in the bay- natural recovery is proposed by the RAP Stage 2.
Nipigon Bay AOC (ON) Localized areas of sediment contaminants in bay/AOC	Pulp-paper mill and municipal WWTPs	Metals	Secondary treatment has been installed at the mill. No sediment remediation is planned.
Thunder Bay AOC (ON)	Forest products industry (pulp-paper and wood preserving) historic discharge from chlor-alkali plant, municipal WWTP	Metals including Hg, persistent chlorinated organics, PCBs, PAHs, pentachlorophenol	The City of Thunder Bay has committed to completing a secondary sewage treatment facility by 2002.
Inner Harbor	Northern Wood Preservers, historical chlor-alkali plant discharge	Mercury, Penta-chlorophenol, creosote, PAHs, dioxins, furans	Chlor-alkali plant shut down 1968. Northern Wood Preservers sediment remediation and site contaminant project began 1997. Work is still underway.
Lower Kaministiqua River	Pulp and paper mills	Persistent chlorinated organics, metals	Secondary treatment of all mill discharges. River sediments have been dredged and placed in confined dredge spoils site.

Notes:

AOC = Great Lakes Area of Concern for Remedial Action Plans

AOX = Adsorbable Organic Halides

PAHs = Polycyclic Aromatic Hydrocarbons – a class of organic compounds. PAHs are Lakewide Remediation Critical Pollutants for Lake Superior.

POTW = Publicly Owned Treatment Works (wastewater treatment)

RAP = Remedial Action Plan for Great Lakes Areas of Concern

RCRA = Resource Conservation and Recovery Act (U.S.)

WLSSD = Western Lake Sanitary District in Duluth, MN

WWTP = Wastewater Treatment Plant

4.5 MONITORING STRATEGIES

This LaMP proposes the strategies and actions that LSBP agencies, businesses, and citizens would be required to take in order to reduce and eventually eliminate the load of critical pollutants to Lake Superior. Measures for assessing progress in implementing the reduction strategies and actions are described in Chapters 2 and 3. In addition to implementing these actions, however, pollutant sources and ambient pollutant levels in Lake Superior should also be monitored to assess progress in achieving the goals of the LaMP.

This section provides a menu of possible monitoring activities that could be pursued to evaluate progress toward Lake Superior goals. These ideas are taken from the Chemical Contaminants Chapter (LSBP 1998) of the "Ecosystems Principles and Objectives, Indicators, and Targets for Lake Superior" discussion paper (LSBP 1995). More work is needed to develop a coordinated monitoring program that will enable the LSBP agencies to evaluate progress toward the Lake Superior goals. This effort should include source monitoring to determine and track releases of toxic pollutants as well as environmental monitoring for the Lake Superior ecosystem. The agencies will undertake the following:

Binational Action:

(199) The EPA and EC will lead efforts to develop a coordinated monitoring strategy for the Lake Superior basin. All of the LSBP agencies will assist in the development of the monitoring strategy and seek resources for implementation. The monitoring strategy will be peer reviewed and presented in LaMP 2002. (BR, EC, EPA, FDL, GP, KBIC, MI, MN, ON, RC, WI)

In addition to environmental and source monitoring for critical pollutants, research is needed on important questions related to toxic substances and their fate in the Lake Superior ecosystem. Research needs will be addressed in future iterations of the LaMP.

4.5.1 GOALS

The purpose of monitoring is to document progress toward the following:

- The virtual elimination of inputs of the designated nine pollutants,
- The virtual elimination of the designated nine pollutants from Lake Superior basin ecosystems, and
- The elimination of critical pollutant based impairments to the beneficial uses of environmental resources.

Monitoring, with regard to chemicals, is divided into source monitoring and environmental monitoring. Each is discussed below.

4.5.1.1 Source Monitoring

Source monitoring includes the measurement of the amount of a critical pollutant being released into the environment from an anthropogenic source, documenting the human activities that contribute to the release of critical pollutants, and documenting the locations and amounts of the critical pollutants within the basin. Source monitoring is the method for documenting the virtual elimination of inputs to the environment of the nine designated pollutants.

4.5.1.2 Environmental Monitoring

Environmental monitoring is the analytical quantification of contaminant concentrations in various biotic and abiotic entities in the environment. These measured concentrations can be used to determine contaminant trends over time. This monitoring activity is designed to document the virtual elimination of the nine designated pollutants from Lake Superior basin ecosystems.

4.5.2 STRATEGIES

4.5.2.1 Source Monitoring

Options for source monitoring programs include the following:

- (M1) Concentrations and loads in discharges to water from permitted facilities
- (M2) Concentrations and loads in emissions to air from permitted facilities
- (M3) Continued atmospheric emission estimates for the program using the RAPIDS system
- (M4) Concentrations and loads in biosolids (sludge) from permitted facilities
- (M5) Quantity of mercury-bearing products such as thermometers, switches, thermostats, paint, and batteries purchased in the basin
- (M6) Quantity of mercury recovered in sweeps, including household hazardous waste, commercial hazardous waste, and sweeps done within a facility
- (M7) Quantity of mercury used and disposed of by medical and dental facilities
- (M8) Use of mercury- or dioxin-contaminated feedstock chemicals
- (M9) Production of electricity
- (M10) Quantity of PCB-bearing equipment phased out in the basin
- (M11) Mass of PCBs, HCB, mercury, and dioxin included in sediment remediation projects
- (M12) Quantity of chlordane, DDT, dieldrin, HCB, mercury, toxaphene, and dioxin-contaminated pesticides gathered in agricultural waste pesticide collections in the basin

- (M13) Quantity of chlordane, DDT, dieldrin, HCB, mercury, toxaphene, and dioxin-contaminated pesticides gathered in household hazardous waste collections
- (M14) Combustion of different fuels (for example, wood, coal, gas, railroad ties, or tires) for energy and the amounts of dioxin and mercury released
- (M15) Mining production and the amount of mercury, dioxin, and HCB released through beneficiation processes
- (M16) Amount of solid waste burned in residential or small business incinerators or backyard burn barrels and the amounts of dioxin, HCB, and mercury released
- (M17) Amount of solid waste and medical waste incinerated in the basin and the amounts of dioxin, HCB, OCS, and mercury released
- (M18) Inventory of all PCBs in use and storage in the Lake Superior basin
- (M19) Survey of Very Small-Quantity Generators (VSQG) designed to identify critical pollutants in use or storage
- (M20) Sample sewer mains outside dental clinics with cooperation of the city public works
- (M21) Review hospital purchasing policies and replace mercury-bearing equipment with alternatives
- (M22) Remaining PCBs stored in hospitals to be removed and sent for destruction
- (M23) Review hospital purchases and conduct site inspections
- (M24) Continue STAC program inventory of worst emitters
- (M25) Continue Environmental Effects Monitoring Program (impacts on organisms and biodiversity of receiving waters) as required under federal pulp and paper regulations and continue to monitor the cleanup of the Northern Wood Preservers site using in situ and bioassay results

The following actions support those listed above:

- (M26) “Use trees” for the prevention/investigate chemicals based on the literature search on analytical methods and media, the chemicals will be integrated into the monitoring schedule
- (M27) Look for opportunities to develop common sample collection methodologies and data reporting formats
- (M28) Look for opportunities to develop common databases for data storage and retrieval
- (M29) Develop a web site to report monitoring data to the public; include an e-mail address to allow individuals to report possible sources of pollutants, and then post the messages on the web site
- (M30) Encourage Ontario pulp and paper mills to continue self-monitoring
- (M31) Model for the aggregate impact of pulp and paper mills
- (M32) Amend Ontario MISA monitoring program to include mercury, HCB, and OCS
- (M33) Mass of mercury per BTU in fuel
- (M34) Mass of mercury per ton in taconite ore
- (M35) Use low level detection methods such as mercury method 1631 when sampling discharges
- (M36) Improve estimates of the mercury balances at the taconite facilities

4.5.2.2 Environmental Monitoring

- (M37) Water concentrations of zero discharge chemicals and lake-wide remediation chemicals should be monitored in the offshore waters of Lake Superior and compared to appropriate yardsticks. Samples should be collected at 2-year intervals as described in the Chemical Contaminants Chapter of the EPO (1998).
- (M38) Contaminant concentrations in key fish species will be monitored and compared to "yardsticks." Predetermined sizes of fish will be collected every 5 years. Fish contaminant monitoring objectives and methods should be coordinated with other SWG "theme teams".
- (M39) Sediment concentrations of zero discharge and lake-wide remediation chemicals should be compared to standards and yardsticks. Sediment concentrations of local remediation chemicals in AOCs would be compared to appropriate standards or guidelines used by the jurisdiction. Sediment cores would be collected at 10-year intervals as described in the Chemical Contaminants of the EPO (1998).
- (M40) Concentrations of the designated chemicals will be monitored annually in air and precipitation and at 2-year intervals in water.
- (M41) At 10-year intervals, sediment cores will be taken in depositional offshore zones, sectioned, dated, and analyzed for designated chemicals.
- (M42) Monitor critical pollutants (see Table 2-1 of the Stage 2 LaMP) in a range of organisms that are found in terrestrial, terrestrial/aquatic interface, and aquatic habitats within the Lake Superior basin for the purpose of establishing baseline concentrations, determining chemical trends both temporally and spatially, and evaluating potential toxic effects to organisms by comparing chemical body residues in field organisms to chemical body residues in laboratory organisms that have been correlated to toxic effects.
- (M43) Monitor and assess the nine designated zero discharge chemicals and the lakewide remediation chemicals prior to dredging
- (M44) Monitor and assess the nine designated zero discharge chemicals as part of the environmental review process at sites where the use trees show the potential for their presence or pesticides have been used or stored.
- (M45) As part of Oil Response work on the Great Lakes, the Oil program in Superfund is currently developing maps of the Great Lakes shoreline using GIS technology. The maps include detailed data on location of sensitive species, tribal lands, natural areas and managed lands, economic resources and potential spill sources. The completed maps will be a valuable resource for identification of important habitat in the Lake Superior basin. Superfund commits to completing these maps and providing them to LaMP/RAP partners by the end of FY 2001.

The following actions support those listed above:

- (M46) Total load would be calculated using estimates of wet deposition, dry deposition, and gas exchange collected annually as described in the Chemical Contaminants of the EPO (LSBP 1998).
- (M47) Change in the rate of loading and whether the rate of loading is from the atmosphere to the lake or from the lake to the atmosphere.

- (M48) Look for opportunities to develop common sample collection methodologies and data reporting formats.
- (M49) Look for opportunities to develop common databases for data storage and retrieval.
- (M50) In Canada, a cohesive federal provincial air monitoring program would need to be in place to track load reductions from air emissions.
- (M51) Develop more standardized trace-level sampling and analytical techniques

4.6 PLANNING ACTIVITIES

The focus of efforts over the next two to three years will be on the implementation actions described in this document. However, the Lake Superior LaMP process is iterative and resources will be allocated to the development and implementation of new actions as appropriate until the goals have been achieved. Additional planning activities will be ongoing, and the results will be presented biennially. In addition, progress toward achieving the load reduction milestones will be monitored and reported.

Actions will include the following:

- Biennial preparation of LaMP updates that will (1) identify trends based on monitoring information, (2) detail actions completed; (3) outline commitments for new actions; and (4) document progress toward achieving goals of zero discharge and emission of certain persistent, bioaccumulative or toxic pollutants
- Additional analyses of source categories and prioritization of future load reduction actions
- Preparation and distribution of progress reports for special events such as the State of the Lakes Ecosystem Conference and International Joint Commission biennial meetings
- Preparation and distribution of concise “issue papers” to deal with specific topics of interest (for example, layperson summaries of progress reports, LaMP documents, and success stories)
- Coordination with RAPs and other local monitoring and remediation efforts
- Public outreach to describe steps that basin residents may take to further the goal of zero discharge
- Development of load reduction schedules and reduction strategies for other critical pollutants; remediation of sites already contaminated by these chemicals will be given priority

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ADDENDUM 4-A
COMPOUND ESTIMATES AND ASSUMPTIONS

This addendum documents the data sources and assumptions used to characterize the compound emission, use, and disposal estimates provided in chapters 1 and 5 of this report. The addendum is organized in three subsections:

Addendum A.1: Mercury Emission and Disposal Estimates
Addendum A.2: PCB Use Estimates
Addendum A.3: Dioxin Emission and Disposal Estimates

The assumptions and data sources underlying the pesticide collection information are documented in chapters 1 and 5.

A.1 Mercury Emission and Disposal Estimates

This section is organized into two subsections: A.1.1, U.S. mercury emission and disposal estimates and A.1.2, Canadian mercury emission and disposal estimates. Following the tabular summaries of the emission and disposal estimates (Tables A.1 and A.2) in each section is a description of the specific data sources and assumptions supporting each estimate.

A.1.1 Mercury Emission and Disposal Estimates for the U.S. Lake Superior basin

Table A.1 1990 and 1999 Mercury Emission Estimates For The U.S. Lake Superior basin

Source/Use Category	**1990 Emissions (kg/yr)**			**1990 Use, Disposal, Soils (kg/yr)**	**1999 Emissions (kg /yr)**			**1999 Use, Disposal, Soils (kg/yr)**
	Water	Air	Total Releases		Water	Air	Total Releases	
Industrial								
General industrial activity	0.04	8.9	8.94		0.04	8.9	8.94	
Petroleum refining	0.0006	1.85	1.856		0.006	1.85	1.86	
Industrial Total	**0.05**	**10.8**	**10.85**		**0.05**	**10.75**	**10.8**	
Mining								
Copper		550	550					
Iron		362	362			384.64	384.64	
Mining Total		**912**	**912**			**384.64**	**384.64**	
Fuel Combustion								
Oil		22.6	22.6			22.6	22.6	
Natural Gas		24.8	24.8			24.8	24.8	
Wood		1	1			2.4	2.4	

Table A.1 1990 and 1999 Mercury Emission Estimates For The U.S. Lake Superior basin

Source/Use Category	**1990 Emissions (kg/yr)**			**1990 Use, Disposal, Soils (kg/yr)**	**1999 Emissions (kg /yr)**			**1999 Use, Disposal, Soils (kg/yr)**
	Water	Air	Total Releases		Water	Air	Total Releases	
Coal		88.5	88.5			142.73	142.73	
Fuel Combustion Total		**136.9**	**136.9**			**192.53**	**192.53**	
Incineration								
WLSSD		11.2	11.2			10.95	10.95	
Small incinerators		48	48					48
Other sludge		1	1			1	1	
Medical waste		22.7	22.7			0	0	
Cremation		2.5	2.5			1.50	1.50	
Incineration Total		**85.4**	**85.4**			**13.45**	**13.45**	**48**
Commercial Products								
Dry cell batteries				851				85.1
Electric lighting		14.6	14.6	37.9		0.82	0.82	20.1
Fever thermometers				22.9				22.9
Thermostats				15.9				15.9
Light switches				0.57				0.57
Pigments				14.1				14.1
Paint		131.9	131.9	25.6				
Fungicides		3.8	3.8					
Commercial Products Total		**150.3**	**150.3**	**968**		**0.82**	**0.82**	**158.67**
Commercial/ Municipal Activities								
WLSSD	21.5		21.5		0.46		0.46	9.19
Landfills		38.8	38.8			38.8	38.8	
Dental uses, hospitals, and labs	0.08	0.48	0.56	6.2	0.08	0.48	0.56	6.2
Residential, Other	0.32		0.32		0.32		0.32	
Commercial/Municipal Total	**21.9**	**39.3**	**61.2**	**6.2**	**0.86**	**39.28**	**40.14**	**15.39**
ANTHROPOGENIC TOTAL	21.95	1334.7	1356.65	974.2	0.91	642.4837	643.3937	222.06

It is assumed that the final disposition of 10 percent of mercury in total Commercial/Municipal effluent is in sludge (Lohse-Hanson 1999). Therefore, not including the WLSSD, there was 4 kg/yr of mercury in sludge in 1990 and 4 kg/yr of mercury in sludge in 1999.

Industrial

- General and Petroleum refining: The 1990 estimates were used (LSBP 1999).

Mining

- Copper: White Pines closed (Michigan Mercury Pollution Prevention Task Force 1996)
- Iron: Taconite production estimates for Minnesota (Jiang 1999)

Fuel Combustion

- Oil: 1990 estimates were used (LSBP 1999).
- Natural Gas: 1990 estimates were used (LSBP 1999). The following facilities use natural gas: Hibbing Public Utility, Duluth Steam Plant, GLT-Cloquet, NNG-Carlton, NNG-Wrenshall, USG, Georgia Pacific, and Louisiana Pacific.
- Wood
  - ⇒ The 1999 estimate is 1 pound/year (LSBP 1999)
  - ⇒ MN Power ML Hibbard estimate (3 pounds/year) is based on 1995 emission estimates (Hagley 1999).
  - ⇒ Louisiana Pacific and Georgia Pacific emission estimates based on 1998 estimates for the amount of wood burned and emission factor for wood-burning unit with electrostatic precipitators (ESP) control devices. Louisiana Pacific has ESP and catalytic afterburner for 14,289 tons of wood and a centrifugal collector and fabric filter for 5,026 tons of wood. Georgia Pacific has a multiclone and ESP for 6,327 tons of wood and a ESP on 8,789 tons of wood (Kim 1999). An emission factor was only available for ESP control ($2.6 * 10^{-6}$ pound/ton) (EPA 1997).

    Louisiana Pacific: ($2.6 * 10^{-6}$ pound mercury/ton) * 19,315 tons/year = 0.502 lb mercury/year = 0.023 kg mercury/year

    Georgia Pacific: ($2.6 * 10^{-6}$ pound mercury/ton) * 15,116 tons/year = 0.039 lb mercury/year = 0.018 kg mercury/year
- Coal
  - ⇒ 1990 estimates were based on Minnesota statewide figures, extrapolated to the population of the Lake Superior basin (Tetra Tech Inc. 1996)
  - ⇒ 1999 estimates are based on facility-specific information for the Lake Superior basin
  - ⇒ 1997 mercury emissions for LTV Mining (50 lb/yr), MN Power Laskin Units 1 (17 lb/yr) and 2 (16 lb/yr), Northshore Mining Company (26 lb/yr), and Potlach Corporation (<3 lb/yr) (Oliaei 1999)
  - ⇒ 1998 emissions for NSP Bayfront (2.3 lb/yr) and University of Wisconsin Superior (1.215 lb/yr) (Cabrera-Rivera 1999)
  - ⇒ 1995 emissions for City of Marquette (16 lb/yr) (City of Marquette 1997) and 1998 emissions for Wisconsin Electric (150 lb/yr) (Michaud 1999)

⇒ 1998 emissions for Hibbing Public Utility based on amount of subbituminous coal used in cyclone and spreader stoker units (Kim 1999) multiplied by an emission factor for ESP control (EPA 1997)

64,931 tons/year * (0.052 * 10-3 lb mercury/ton coal) = 3.38 lb

mercury/year = 1.53 kg mercury/year

⇒ 1998 emissions for the Duluth Steam Plant based on amount of pulverized coal used in a dry bottom unit that has a multiclone with a fabric filter (Kim 1999). An emission factor was used for bituminous coal with multiclone control (EPA 1997).

38,198.26 tons of coal/year * (0.78 *10-3 lb mercury/ton coal) = 29.79 lb

mercury/year = 13.51 kg mercury/year

Incineration

- WLSSD: 1999 estimates were provided by the WLSSD (Tuominen 1999).
- Small incinerators: 1990 estimated emissions were moved to the use and disposal category for 1999, since most incinerators in this category have ceased operating since 1990.
- Other sludge: 1990 estimates were used (LSBP 1999).
- Medical waste: Michigan has no medical incinerators remaining in the Lake Superior basin (Troutman 1999), Minnesota has no medical incinerators remaining in the basin (Lohse-Hanson 1999), and Wisconsin has no medical incinerators remaining in the basin (Larson 1999). The 1999 emission estimate was determined by multiplying the amount of medical waste burned by the emission factor for medical waste with combustion control (EPA 1997). This emission factor was the most conservation emission factor available.
- Cremation: The 1999 estimate was determined by calculating what percentage the basin population [425,548] (Tetra Tech Inc. 1996) is of the total Michigan, Minnesota, and Wisconsin 1998 population [19,766,161] (U.S. Census 1998). This percentage (2.15 percent) was multiplied by the number of total projected cremations in Michigan, Minnesota, and Wisconsin for 2000 [46,569] (EPA 1997) to obtain the total number of cremations in the basin. The number of cremated bodies [1,002.6] was multiplied by the emission factor of 1.50E-03 kg/body for cremation (EPA 1997).
  - ⇒ 425,548/19,766,161 = 2.15 percent
  - ⇒ .0215 * 46,569 = 1,002.6
  - ⇒ 1,002.6 bodies/yr * 1.50E-03 kg mercury/body = 1.50375 kg mercury/yr

Commercial Products

- Batteries: A Hennepin County study showed about a 90-94 percent decrease since the early 90's (NEMA 1999). In addition, the volume of mercury used in batteries has declined by over 95 percent (Ross & Associates 1994). Battery sorting studies have shown about a 95 percent decrease in mercury content since the late 1980's (Erdheim 1999). Therefore, 1990 estimates were decreased by 90 percent.
- Electric lighting :

⇒ *Air emissions*: The 1999 estimates are based on a population extrapolation and Minnesota mercury emission estimates from fluorescent lamp breakage for 2000 [9.07 kg/yr], which are based on the proportion of lamps not recycled and industry figures on mg/lamp (MPCA 1999). A U.S. basin population of 425,548 was used (Tetra Tech Inc. 1996).

⇒ 9.07 kg/yr/ 4725419 people in MN = 0.816966 kg/person/yr

⇒ 0.816966 * 425,548 = 0.82

⇒ *Disposal/use*: The average mercury content of a four foot lamp in 1994 was 22.8 mg; the National Electric Manufacturers Association expects the mercury content of a four foot lamp to be < 12 mg [47 percent decrease] by 2000 (EPA and Environment Canada 1998c). Therefore, 1990 estimates were decreased by 47 percent to obtain 1999 estimates.

- Thermometers, thermostats, light switches, pigments: 1990 estimates were used (LSBP 1999).
- Paint and Fungicides: Paint registrations were canceled in 1991 and fungicides were canceled in 1993 (Ross and Associates 1994).

Commercial/Municipal

- WLSSD: 1999 estimates provided by the WLSSD. Half of sludge being generated is applied to land (Tuominen 1999).
- Landfills; dental uses, hospitals, and labs; and residential and other: 1990 estimates were used (LSBP 1999).

Table A.2 1990 and 1999 Mercury Emission Estimates For The Lake Superior Canadian Basin

Source/Use Category	**1990 Emissions (kg/yr)**			**1990 Use, Disposal, Soils (kg/yr)**	**1999 Emissions (kg /yr)**			**1999 Use, Disposal, Soils (kg/yr)**
	Water	Air	Total Releases		Water	Air	Total Releases	
Industrial								
Forest Products	10.99	11	21.99	0.001	10.99	7.86	18.85	0.001
Mining	0.4	604	604.4		0.4	0.015	0.415	
Metal Finishing	1.53		1.53		1.53		1.53	
Photoprocessing	0.003	0.0004	0.003					
Industrial Total	**12.9**	**614**	**627.9**	**0.001**	**12.9**	**7.9**	**20.8**	**0.001**
Fuel Combustion								
Ontario Hydro – Thunder Bay	0.44	100	100.4	10	0.5	50.33	50.83	5

Table A.2 1990 and 1999 Mercury Emission Estimates For The Lake Superior Canadian Basin

Source/Use Category	**1990 Emissions (kg/yr)**			**1990 Use, Disposal, Soils (kg/yr)**	**1999 Emissions (kg /yr)**			**1999 Use, Disposal, Soils (kg/yr)**
	Water	Air	Total Releases		Water	Air	Total Releases	
Oil		8	8			8	8	
Natural Gas		12	12			12	12	
Wood		0.34	0.34			0.34	0.34	
Coal		5	5			5	5	
Fuel Combustion Total	**0.4**	**125.3**	**125.7**	**10**	**0.5**	**75.7**	**76.2**	**5**
Incineration								
Municipal incinerators		0	0			0	0	
Medical waste		0.77	0.77	0.02		0.41	0.41	
Cremation		1.1	1.1			0.7	0.7	
Incineration Total		**1.9**	**1.9**	**0.02**		**1.1**	**1.1**	
Commercial Products								
Batteries				300				15
Electric lighting		1	1	15.8*		0.5	0.5	7.8*
Fever thermometers				11.2*				11.4*
Thermostats				7.0*				5.8*
Light switches				1.2*				1.2*
Pigments				5.6				5.6
Paint	21.2	0.12	21.32		0	0	0	0
Fungicides	0.8	8	8.8	7.2	0	0	0	0
Instruments (other)		13.1	13.1	52.35		13.1	13.1	52.35
Commercial ProductsTotal	**22.0**	**22.2**	**44.2**	**400.4**		**13.6**	**13.6**	**99.2**
Commercial/ Municipal Activities								
Wastewater treatment plants	3.89	4.63	8.52	2.08	3.89	4.63	8.52	2.08
Runoff	0.7		0.7		0.7		0.7	
Dental		0.18	0.18	22.5**		0.18	0.18	22.5**
Pharmaceutical		1.26	1.26			1.26	1.26	
Commercial/Municipal Total	**4.59**	**6.07**	**10.66**	**24.6**	**4.59**	**6.07**	**10.66**	**24.6**
ANTHROPOGENIC TOTAL	**39.95**	**769.5**	**810.4**	**435.0**	**18.0**	**104.3**	**122.3**	**128.7**

* Estimates of the amount of mercury in these products disposed in landfills
** Part of this estimate is a doublecount under wastewater treatment plants.

A.1.2 Mercury Emission and Disposal Estimates for the Canadian Lake Superior Basin

Industrial

- Forest Products: The 1999 estimate includes 1995 estimates for Kimberly Clark, Avenor-Thunder Bay, Abitibi Price - Prov. Paper, Abitibi Price Fort William, Northern Wood Preserves, Norampac Packaging-RR, Weldwood of Canada Ltd., and Fort James-Marathon (Brigham 1999)
- Mining : The Algoma Steel Plant in Wawa, Ontario closed. The 1999 estimate includes the 1995 estimate for Williams Operations gold ore (Brigham 1999).
- Metal Finishing and Photoprocessing: The 1990 estimates were used (Thompson 1994).

Fuel Combustion

- Oil, Natural Gas, Wood, and Coal: The 1990 estimates were used (LSBP 1999).

Incineration

- There is no municipal incineration in the Lake Superior basin
- Medical waste: The 1990 estimates are for hospitals open in 1993 (Brigham 1999). The 1999 estimate includes 1995 estimates for the hospitals that continue to operate incinerators: St. Joseph's General and McClausland hospitals (Brigham 1999).
- Cremation: The 1990 estimate is from Thompson (1994). The 1999 estimate includes 1995 estimates for Riverside Cemetery and Sunset Crematorium (Brigham 1999).

Commercial Products

- Batteries - A Hennepin County (in Minnesota) study showed about a 90-94 percent decrease since the early 90's (NEMA 1999). In addition, the volume of mercury used in batteries has declined by over 95 percent (Ross & Associates 1994). Battery sorting studies have shown about a 95 percent decrease in mercury content since the late 1980's (Erdheim 1999). Therefore, 1990 estimates were decreased by 95 percent.
- Electric lighting, fever thermometers, thermostats and light switches estimates are from Benazon (1998)
- Paint and fungicide estimates are from Benazon (1998). Turf fungicides and mercury in paint are now banned and releases are assumed to be zero (Benazon 1998)
- Pigments: 1990 estimates were used (LSBP 1999).

Commercial/Municipal Activities

- Wastewater Treatment Plants, Runoff, Pharmaceuticals: 1990 estimates were used (LSBP 1999).
- Dental: The losses to the atmosphere are due to placement and removal of amalgams (Benazon 1998). The draft *Canadian Emissions Inventory of Mercury* assumes a weight of 0.2 g mercury in each amalgam. The estimate for amalgam disposal comes from Thompson (1994).
- Pharmaceutical emissions are from the mercury in skin preparations and diuretics. Estimates used are from Thompson (1994)

A.2 PCB USE ESTIMATES

This section is organized into two sections. Section A.2.1 summarizes PCB use estimates for the U.S. portion of the Lake Superior basin, and section A.2.2 provides documentation for PCB use in the Canadian portion of the basin.

A.2.1 PCB Estimates for the U.S. Lake Superior basin

- Methods used to extrapolate MPCA capacitor and transformer data to Lake Superior basin:

Population of Minnesota in Lake Superior basin:	232,928
Minnesota MPCA data:	
Number of capacitors > 500 ppm (Minnesota Power)	2935
Number of capacitors > 500 ppm (other industry/utilities)	418
Number of transformers and capacitors < 500 ppm	195
Capacitors > 500 ppm PCB per capita (industry/utilities other than MN Power), 1.79x10-3	
Transformers and capacitors < 500 ppm PCB per capita, Minnesota	8.73x10-4
Capacitors > 500 ppm PCB in basin (1.79x10-3 x 232,928 + 2935 MN Power)	**3353**
Transformers and capacitors < 500 ppm PCB in basin (8.73x10-4 x 232,928)	**195**

- Method for determining the mass of PCB in U.S. portion of basin from transformers > 500 ppm PCB and all capacitors:

*Assumptions re: volume and concentrations**

Capacitors > 500 ppm	3 gallons & 175,000 ppm each
Transformers < 500 ppm**	
95.5 percent	15 gallons & 150 ppm each
0.5 percent	2500 gallons & 250 ppm each
Transformers > 500 ppm	15 gallons & 550 ppm each

* Equipment volume and concentration estimates based on personal communication with Gene Beadey, Minnesota Power PCB Program Manager (Beadey 1999)

** also applied to capacitors < 500 ppm

Calculations to find mass of PCBs

# caps > 500 ppm		326
Volume of caps > 500ppm	(3353 x 3 gal)	10,059 gal
Volume of caps > 500ppm	(10,059 gal x 3.785 liters/gal)	38,077 liters
Mass PCB***	(38,077 liters x 175,000 ppm [mg/l] / 1000000 mg/kg)	**6664 kg**
# caps & tfs < 500 ppm		195
Volume of tfs < 500 ppm, 15 gal	(195 caps x .955 x 15 gal)	2793 gal
Volume of tfs < 500 ppm, 15 gal	(2793 gal x 3.785 liters/gal)	10,574 liters
Mass PCB***, 15 gal	(10,574 liters x 150 ppm [mg/l]/ 1000000 mg/kg)	**1 kg**
Volume tfs < 500 ppm, 2500 gal	(195 caps x .005 x 2500 gal)	2438 gal

Volume tfs < 500 ppm, 2500 gal	(2438 gal x 3.785 liters/gal)	9227 liters
Mass PCB***, 2500 gal	(9227 liters x 150 ppm [mg/l]/ 1000000 mg/kg)	**2 kg**

*** assuming ppm = mg/l, thus density of oil = 1

TOTAL **6667 kg**

- Note regarding U.S. treatment of PCB generating processes

U.S. EPA has concluded that the quantity of PCBs inadvertently generated and released into the environment is inconsequential compared to releases from items with intentional PCBs and, therefore, did not ban these processes. However, U.S. EPA did add certification, recordkeeping and reporting requirements to the facilities that inadvertently produce PCBs. (EPA 1998a)

A.2.2 PCB Estimates for the Canadian Lake Superior basin

- 1997 data for Canada are from Brigham (1999)
- In Canada, quantities are reported as PCB contaminated materials and fluids. Liquids are generally reported in liters. Conversion to kilograms was made assuming 1.15 kg/liter.
- 1990 data for Canada were taken from the Stage 2 LaMP.
- Data for total quantity destroyed in Canada are from pgs 30 and 37 of the Zero Discharge report, adding all of the data for the provincially monitored sites and the total for the federally monitored sites. However, pg 36 of the Zero Discharge report provides higher quantities for provincially monitored sites (in the summary table) and would result in a total of 435,949 kg destroyed between 1990-1997, a difference of 91,918 kg. The data presented are for provincially monitored and federally monitored sites and are not presented by sector.
- The total amount of PCBs in use in Canada in 1997 is drawn from the Zero Discharge report, pg 31, indicating the total quantity of high level PCB liquids only. It is not known whether there is an additional quantity of low level PCB liquids still in use in 1997.
- Though it would appear that Canada has already exceeded the reduction goals for 2005 based upon the quantity destroyed 1990- 1997 (as presented in the Zero Discharge report) and the baseline quantity in use and storage in 1990 (as presented in the Stage 2 LaMP), there is an additional 96,012 kg in use and storage in 1997 (as presented in the Zero Discharge report). The reason for this discrepancy is not known, though it may be the result of the discovery of additional PCB storage and use since completion of the 1990 inventory.
- High level liquid and solid PCB materials are defined as containing greater than 10,000 ppm PCBs.
- Low level liquid and solid PCB materials are defined as containing 50-10,000 ppm PCBs.
- The federally monitored sites do not report whether the stored materials are high or low level waste and, therefore, it is all classified as high level waste.

A.3 DIOXIN EMISSION AND DISPOSAL ESTIMATES

This addendum is organized in two sections. Addendum A.3.1 summarizes dioxin emission and disposal estimates for the U.S. portion of the basin, and Addendum A.3.2 provides estimates for the Canadian portion of the basin.

A.3.1 Dioxin Emission Estimates for the U.S. Lake Superior basin

Table A.3.1 summarizes U.S. estimates for the 1990 baseline and 1999.

Table A.3.1 U.S. Lake Superior basin Dioxin Emission and Disposal Estimates

Source/Use Category	1990 Emissions (g TEQ/yr)			1990 Use, Disposal, Soils (g TEQ/yr)	1999 Emissions (g TEQ/yr)			1999 Use, Disposal, Soils (g TEQ/yr)
	Water	Air	Total Releases		Water	Air	Total Releases	
INDUSTRIAL								
Forest products	0 – 0.6		0 – 0.6		0-0.3		0 - 0.3	
Petroleum refining	$1.5x10^{-5}$		$1.5x10^{-5}$					
Wood preserving				$2.9x\ 10^{-3}$ [a]				$2.9x\ 10^{-3}$
Mining		0.1	0.1					
Industrial Total	**$1.5x10^{-5}$-0.6**	**0.1**	**0.1-0.7**	**$2.9x\ 10^{-3}$**	**0-0.6**		**0 - 0.6**	
FUEL COMBUSTION								
Coal		0.73	0.73			0.53	0.53	
Wood		2.7	2.7			0.40	0.40	
Fuel Combustion Total		**3.43**	**3.43**			**0.93**	**0.93**	
INCINERATION								
Burn barrels						6.97	6.97	
Medical and industrial		134	134			83	83	
Small incinerators		235 – 2,274	235 – 2,274					
WLSSD		0.19	0.19			0.19	0.19	
Incineration Total		**369 - 2408**	**369 – 2,408**			**90.2**	**90.2**	
MUNICIPAL/ RESIDENTIAL								
Wastewater treatment plant sludge				0.014				0.014

Table A.3.1 U.S. Lake Superior basin Dioxin Emission and Disposal Estimates

Source/Use Category	1990 Emissions (g TEQ/yr)			1990 Use, Disposal, Soils (g TEQ/yr)	1999 Emissions (g TEQ/yr)			1999 Use, Disposal, Soils (g TEQ/yr)
	Water	Air	Total Releases		Water	Air	Total Releases	
Municipal/Residential Total				**0.014**				**0.014**
COMMERCIAL PRODUCTS								
Pentachlorophenol use				18.0				18.0
PCB spills				0.0006				0.0006
Commercial Products Total				**18.0**				**18.0**
TOTAL	**0.8**	**373 – 2,412**	**374 – 2,413**	**18**	**0.06**	**90.2**	**90.2**	**18.0**

[a] Estimate of dioxin presence in soils at one site in the U.S. portion of the basin. This is not an annual release.

Summary of Sector Assumptions

Industrial

- Forest products: Dioxins are generated in pulp and paper mills from the paper bleaching process, especially in plants using elemental chlorine as a bleaching agent. In recent years, pulp mills in the basin have modified their bleaching processes by substituting chlorine dioxide for elemental chlorine, thereby virtually eliminating dioxins from pulp and paper mill effluents (Stromberg et. al. 1996). However, low level monitoring data were not available to assess the degree to which dioxin effluent concentrations have declined since 1990 for the five pulp and paper mills in the U.S. portion of the basin (two of which discharge directly to the lake). As a result, the 1990 baseline estimate of 0 to 0.6 g TEQ/yr included only the two facilities discharging to Lake Superior, one of which has since closed. The other three mills discharge to Western Lake Superior Sanitary District (WSLSSD). The 1999 estimate has been reduced to 0 to 0.3 TEQ/yr.
- Petroleum refining: Dioxins can be formed when catalysts used in petroleum refining are reactivated by burning off coke deposits at 380 degrees C to 525 degrees C in the presence of chlorinated compounds (Bear et. al. 1993). The Stage 1 LaMP (1995) reported an estimate of 1.5 x 10-5 TEQ/yr discharged in the Murphy Oil refinery wastewater effluent prior to 1991. The refinery is located in Superior, Wisconsin. The dioxin estimate was based on the results of one sample detection. Since 1991 the wastewater discharge permit has prohibited discharge of catalytic reformer regeneration wastewater, which is generated periodically and

is a potential source of dioxin. This waste is segregated and disposed off site at an approved facility. Subsequent permit reissuance and compliance monitoring of refinery wastewater effluent has not detected dioxin (detection limit less than 10 pg/l).

- Wood preserving: Past industrial use of pentachlorophenols (PCP) to treat timber, railroad ties, and utility poles are a potential source of dioxins in the basin (Tetra Tech 1996). The estimate of dioxin contamination in soil is based on an estimate of pentachlorophenol present in soils in the vicinity of the Koppers Inc. facility in Superior, Wisconsin. The facility used PCP to treat railroad ties until 1979. Characterization studies under Resource Conservation and Recovery Act (RCRA) corrective action are ongoing at the site.
- Mining: Non-ferrous metal, especially copper, smelting and refining are a known source of dioxin emissions accounting for approximately 1.36×10^{-2} lb/yr TEQ air emissions in the United States (EPA 1997). In the U.S. portion of the Lake Superior basin, the Copper Range, White Pine Mine smelter operated in Northern Michigan until 1995. With the closure of the White Pine mine smelter, dioxin emissions from copper smelting were eliminated from the U.S. portion of the basin.

Fuel Combustion

The combustion of wood and coal as an energy source for industrial and residential use is a known source of dioxins (EPA 1997). Increased attention has been devoted over the past several years to estimate the dioxin emission factors associated with these processes. Table A.3.2 provides estimates of the wood and coal combustion rates in the U.S. portion of the LSB and the current emission factors used to estimate dioxin TEQ emissions from those sources.

Table A.3.2 Estimated Dioxin Emissions from Wood and Coal Combustion

Fuel and Combustion Type	Quantity of Fuel Burned in U.S. Lake Superior basin (kg)[a]	Emission Factor (ng TEQ/kg fuel combusted)	Dioxin Emissions (g TEQ/yr)[d]
Coal, coal fired utilities and industrial boilers	1.8×10^9	0.087[b]	0.16
Coal, commercial and residential boilers	1.7×10^7	22[c]	0.37
Wood, industrial wood furnace	1.2×10^8	0.82[b]	0.10
Wood, commercial and residential	1.5×10^8	2[b]	0.30
TOTAL			0.93

[a] Adapted from Tetra Tech (1996).
[b] EPA 1998
[c] Tetra Tech 1996
[d] 1 ng = 10^{-9} g

Incineration

- Burn Barrels: In the 1990 baseline estimate, private household waste incineration was not assessed as a source of dioxin air emissions because of an absence of data to characterize the source. In the past several years, additional research has found that household "burn barrels" may be a significant dioxin source. WLSSD (1992) estimated that burn barrels produce 20 times more 2,3,7,8-TCDD per unit of household garbage burned than a controlled incinerator (e.g., a municipal waste combustor (MWC)). Lemieux (1998) estimated that 1.5 to 4 households that burn their waste in the open (e.g., in burn barrels) equal the dioxin generating potential of a fully-operational MWC. Overall, household waste combustion in burn barrels appears to be an overlooked, but potentially significant source of dioxin and other toxic air emissions.
  The average person in the U.S. generates between 800 and 1,350 pounds of household waste in a year (MDEQ 1999). The U.S. EPA estimates that 40 percent of people living in non-metropolitan areas burn their waste and that 63 percent of their daily waste is burned in burn barrels. Nationally, this amounts to over 1.8 billions pound of household waste burned in burn barrels every year. Normalized for the U.S. Lake Superior basin population, this amounts to over 4.5 million pounds of household waste openly burned in the basin each year. While such household waste burning is suspected to be a significant source of dioxin and other toxic air emissions, research findings differ as to the rates of dioxin emission per unit of household waste burned (Cohen 1999). Table A.3.3 summarizes dioxin generation emission factors for several recent studies. The table illustrates that emission rate estimates vary over several orders of magnitude. As a result, these emission factor estimates are provided to illustrate the potential significance of the source. Much additional work remains to be completed to properly estimate the dioxin emissions from household waste burning that is occurring in the basin.

Table A.3.3 Emission Factors for Household Waste Combustion in Burn Barrels

Source	Emission Factor (g TCDD/lb household waste burned)
Cohen (1999)	3.6×10^{-8} [b]
Lemieux (1998) (recycler)[a]	1.04×10^{-7}
Lemieux (1998) (non-recycler)	7.4×10^{-6}
Two Rivers Regional Council (1994)	6.2×10^{-10}
WLSSD (1992)	1.8×10^{-9}

[a] Recyclers were assumed to reduce the proportion of newspaper, plastic, and some metals in their household waste.

[b] Expressed as grams TEQ/yr.

To illustrate the potential magnitude of household hazardous waste burning in the U.S. portion of the basin, Table A.3.4 applies the Cohen (1999) emission factor to potential household hazardous waste burn rates in the U.S. Lake Superior basin counties to generate an annual TEQ dioxin emission estimate. Extrapolation of national estimates on burning rates to the Lake Superior basin yields an estimate of about 7g TEQ/yr.

Table A.3.4 Estimates of Dioxin Generated from Household Waste Combustion in Burn Barrels

County Name	State Name	Population 1996	Estimated Annual Waste Generation (pounds)	Estimated Annual Pounds Burned	Estimated g TEQ/yr Emissions
St. Louis	Minnesota	196,101	264,736,350	66,184,087.	2.38
Lake	Minnesota	10,500	14,175,000	3,543,750	0.13
Bayfield	Wisconsin	15,037	20,299,950	5,074,987	0.18
Carlton	Minnesota	30,554	41,247,900	10,311,975	0.37
Douglas	Wisconsin	43,015	58,070,250	14,517,562	0.52
Ashland	Wisconsin	16,534	22,320,900	5,580,225	0.20
Iron	Wisconsin	6,616	8,931,600.00	2,232,900	0.08
Cook	Minnesota	4,546	6,137,100	1,534,275	0.06
Keweenaw	Michigan	1,988	2,683,800	670,950	0.02
Houghton	Michigan	36,853	49,751,550	12,437,887	0.45
Ontonagon	Michigan	8,625	11,643,750	2,910,937	0.10
Baraga	Michigan	8,182	11,045,700	2,761,425	0.10
Marquette	Michigan	70,457	95,116,950	23,779,237	0.86
Gogebic	Michigan	18,158	24,513,300	6,128,325	0.22
Luce	Michigan	5,548	7,489,800	1,872,450	0.07
Alger	Michigan	9,859	13,309,650	3,327,412	0.12
Schoolcraft	Michigan	8,806	11,888,100	2,972,025	0.11
Iron	Michigan	13,209	17,832,150	4,458,037	0.16
Mackinac	Michigan	11,077	14,953,950	3,738,487	0.13
Chippewa	Michigan	37,587	50,742,450	12,685,612	0.46
Total		653,753	882,566,550	220,641,637	6.72

- Medical and industrial: In the 1990 baseline estimate, medical and industrial incinerators were estimated to contribute 134 g TEQ/yr in dioxin air emissions. As of 1999, all medical incinerators have been closed in the U.S. portion of the basin. The remaining industrial incinerators are estimated to account for approximately 83 g TEQ/yr (after Jackson 1993) in air emissions. As a result, dioxin air emissions are estimated to have declined to 83 g TEQ/yr for this sector in 1999.
- Small incinerators: In the 1990 baseline, small incinerators (e.g., those operated by schools, apartment buildings , and retailers) were estimated to contribute 235 to 2,274 g TEQ/yr in dioxin air emissions. As of 1999, all small incinerators are assumed to be closed in the U.S. portion of the basin. As a result, no dioxin air emissions are estimated for this sector in 1999.
- WLSSD: The Western Lake Superior Sanitary District (WLSSD) operates the only municipal solid waste incinerator in the basin (Stage 2 LaMP 1999). Estimated dioxin releases of 0.19 g TEQ/yr are based on stack testing. This incinerator is expected to close in 2000.

Municipal/Residential

- Wastewater treatment plant sludge: The WLSSD receives indirect discharges from three pulp and paper mills, as well as other industrial and commercial facilities. In addition, new cotton clothing and other household items have also been found to contain dioxins, which come out in the wash and are discharged to the wastewater treatment facility (Horstmann and McLachlan 1994). In 1990, WLSSD treatment plant sludge contained 0.014 g TEQ. Dioxin TEQ concentrations are assumed to remain constant in 1999.

Commercial Products

- Pentachlorophenol use: Pentachlorophenol has been used to preserve a variety of commercial products, including textiles and leather goods in the United States and abroad. In the past, pentachlorophenol was widely used as a pesticide although most of those uses are now restricted. Dioxin contamination in pentachlorophenol could contribute as much as 10,500 g TEQ dioxins/yr in the United States (Slants and Trends 1995). Based upon the normalized population of the LSB, approximately 18.0 g TEQ/yr of dioxin are assumed to be found in the basin. The 1990 estimate was based on this national figure. A 1999 estimate should probably show a decrease because of declining use of pentachlorophenol. However, no updated estimates are available.

A.3.2 Dioxin Emission Estimates for the Canadian Lake Superior basin

Table A.3.5 summarizes the estimated dioxin emissions in the Canadian portion of the Lake Superior basin 1990 to 1999. The assumptions used to generate these estimates are presented in the following section.

Table A.3.5 Canadian Lake Superior basin Dioxin Emission and Disposal Estimates

Source/Use Category	1990 Emissions (g/yr)			1990 Use, Disposal, Soils (g /yr)	1999 Emissions (g /yr)			1999 Use, Disposal, Soils (g /yr)
	Water	Air	Total Releases		Water	Air	Total Releases	
INDUSTRIAL								
Forest products	0.47	0.09	0.56	13.18	0.47	0.09	0.56	13.18
Mining/Sintering		21.8	21.8					
Wood preserving	1.52		1.52	1.53	1.52		1.52	1.53
Contaminated Soils			**0.1**	**31.38**[a]				
Industrial Total	**1.99**	**21.89**	**23.88**	**14.71**	**1.99**	**0.09**	**2.08**	**14.71**
FUEL COMBUSTION								
Coal		0.89	0.89	0.001		0.89	0.89	0.001
Wood		0.08	0.08			0.08	0.08	
Natural Gas		0.05	0.05			0.05	0.05	
Gasoline		0.02	0.02			0.02	0.02	
Fuel Combustion Total		**1.04**	**1.04**			**1.04**	**1.04**	
INCINERATION								
Medical		0.13	0.13	94		0.13	0.13	94
Small incinerators		NA						
Incineration Total		**0.13**	**0.13**	**94**		**0.13**	**0.13**	**94**
MUNICIPAL/RESIDENTIAL								
Wastewater treatment plant sludge	0.04	0.01	0.05		0.04	0.01	0.05	
Municipal/Residential Total	**0.04**	**0.01**	**0.05**		**0.04**	**0.01**	**0.05**	
COMMERCIAL PRODUCTS								
Pentachlorophenol use		0.27	0.27			0.27	0.27	
PCB spills			0.003	70[b]			0.003	70[b]
Commercial Products Total		**0.27**	**0.27**			**0.27**	**0.27**	
TOTAL	**2.03**	**23.34**	**25.37**	**108.71**	**2.03**	**1.48**	**3.51**	**108.7**

[a] Contaminated soils – not an annual rate of disposal.

[b] Resulting from spills – not included in annual disposal estimate.

All 1990 estimates are drawn from the Stage 2 LaMP (LSBP 1999) and are expressed in terms of dioxins and furans, rather than TEQs. As a result, the values are not directly analogous to the U.S. estimates reported in Table A.3.1, unless specifically noted .

Emissions and dioxin/furan levels in soil and disposal are assumed to remain constant through 1999 except for the following changes:

Industrial

- Forest Products: Yearly average dioxin concentrations in the wastewater effluent form the Kraft mills in the Thunder Bay Region have generally declined form 1990 to 1994, although information on total dioxin load has not been reported. As a result, dioxin load in wastewater from this sector is assumed to remain constant from 1990 to 1999 (Brigham 1999).
- Mining/Sintering: The Algoma Ore Division iron sintering plant in Wawa, Ontario closed in 1998, thereby eliminating the 21.8 g/yr in dioxin emissions estimated for this sector in 1990.

Incineration

- Medical: The number of medical incinerators in the Canadian Lake Superior basin has declined from seven in 1990 to three in 1999 (Brigham 1999). As a result, dioxin emissions are assumed to have declined proportionally to 0.07 g dioxin/yr.

ADDENDUM 4-B
CHALLENGES BY THE GREAT LAKES BINATIONAL TOXICS STRATEGY

Addendum 4-B contains the challenges section of the Great Lakes Binational Toxics Strategy.

Challenges

EC and U.S. EPA, working in cooperation with their partners, accept the following challenges as significant milestones on the path toward virtual elimination. These milestones will be achieved by implementing voluntary efforts to achieve reductions of particular Level I substances and through currently anticipated regulatory actions under environmental laws in both countries. In Canada, the baseline used for these milestones will be 1988, in keeping with the Accelerated Reduction and Elimination of Toxics Program (ARET) baseline and the 1987 GLWQA. For the U.S., the baseline from which reductions will be measured is unique for each substance, the best available data will be used, which in most cases is the most recent baseline.

As new information and data on opportunities, and their associated costs and benefits become available, EC and U.S. EPA may revise the milestones, using a public consultation process involving their partners. In some cases, the challenges may differ between EC and USEPA based on different start dates for their respective domestic toxics reduction programs, different regulatory and legislative authorities, and different chemical data bases, baselines and inventories.

EC and U.S. EPA will work with their partners to:

- U.S. Challenge: Confirm by 1998 that there is no longer use or release from sources that enter the Great Lakes basin of five bioaccumulative pesticides (chlordane, aldrin/dieldrin, DDT, mirex, and toxaphene), and of the industrial byproduct/contaminant octachlorostyrene. If ongoing, long-range sources of these substances from outside of the U.S. are confirmed, work within international frameworks to reduce or phase out releases of these substances.
  Canadian Challenge: Report by 1997, that there is no longer use, generation or release from Ontario sources that enter the Great Lakes of five bioaccumulative pesticides (chlordane, aldrin/dieldrin, DDT, mirex, and toxaphene), and of the industrial byproduct/contaminant octachlorostyrene. If ongoing, long-range sources of these substances from outside of Canada are confirmed, work within international frameworks to reduce or phase out releases of these substances.

- U.S. Challenge: Confirm by 1998, that there is no longer use of alkyl-lead in automotive gasoline. Support and encourage stakeholder efforts to reduce alkyl-lead releases from other sources.
  Canadian Challenge: Seek by 2000, a 90 percent reduction in use, generation, or release of alkyl-lead consistent with the 1994 COA.

- U.S. Challenge: Seek by 2006, a 90 percent reduction nationally of high-level PCBs (>500 ppm) used in electrical equipment. Ensure that all PCBs retired from use are properly managed and disposed of to prevent accidental releases within or to the Great Lakes basin.
  Canadian Challenge: Seek by 2000, a 90 percent reduction of high-level PCBs (>1 percent PCB) that were once, or are currently, in service and accelerate destruction of stored high-level PCB wastes which have the potential to enter the Great Lakes basin, consistent with the 1994 COA.

- U.S. Challenge: Seek by 2006, a 50 percent reduction nationally in the deliberate use of mercury and a 50 percent reduction in the release of mercury from sources resulting from human activity. The release challenge will apply to the aggregate of releases to the air nationwide and of releases to the water within the Great Lakes basin. This target is considered as an interim reduction target and, in consultation with stakeholders, will be revised if warranted, following completion of the Mercury Study Report to Congress.
  Canadian Challenge: Seek by 2000, a 90 percent reduction in the release of mercury, or where warranted the use of mercury, from polluting sources resulting from human activity in the Great Lakes basin. This target is considered as an interim reduction target and, in consultation with stakeholders in the Great Lakes basin, will be revised if warranted, following completion of the 1997 COA review of mercury use, generation, and release from Ontario sources.

- U.S. Challenge: Seek by 2006, a 75 percent reduction in total releases of dioxins and furans (2,3,7,8-TCDD toxicity equivalents) from sources resulting from human activity. This challenge will apply to the aggregate of releases to the air nationwide and of releases to the water within the Great Lakes basin. Seek by 2006, reductions in releases, that are within, or have the potential to enter the Great Lakes basin, of hexachlorobenzene (HCB) and benzo(a)pyrene [B(a)P] from sources resulting from human activity.
  Canadian Challenge: Seek by 2000, a 90 percent reduction in releases of dioxins, furans, HCB, and B(a)P, from sources resulting from human activity in the Great Lakes basin, consistent with the 1994 COA. Actions will focus on the 2,3,7,8 substituted congeners of dioxins and furans in a manner consistent with the TSMP.

- U.S. and Canadian Challenge: Promote pollution prevention and the sound management of Level II substances, to reduce levels in the environment of those substances nominated jointly by both countries, and to conform with the laws and policies of each country, including pollution prevention, with respect to those substances nominated by only one country. Increase knowledge on sources and environmental levels of these substances.

- U.S. and Canadian Challenge: Assess atmospheric inputs of Strategy substances to the Great Lakes. The aim of this effort is to evaluate and report jointly on the contribution and significance of long-range transport of Strategy substances from world-wide sources. If ongoing long-range sources are confirmed, work within international frameworks to reduce releases of such substances.

- U.S. and Canadian Challenge: Complete or be well advanced in remediation of priority sites with contaminated bottom sediments in the Great Lakes basin by 2006.

Chapter 5

Human Health Information

Insert at the beginning of LaMP 2004 Chapter 5.

Smelting, Lake Superior, Minnesota
Photograph by Minnesota Sea Grant

Lake Superior Lakewide Management Plan
2004

Chapter 5 Contents

Chapter 5
Human Health Information

5.0 INTRODUCTION

The Lake Superior LaMP seeks to restore and protect the beneficial uses of the Great Lakes, such as safe beaches, clean drinking water and healthy fish and wildlife populations. Awareness of the underlying causes of these beneficial use restrictions from chemical and microbial contaminants, and the associated health consequences,will allow public health agencies to develop societal responses protective of public health.

The beneficial uses related to human health include ‘Swimmability’, ‘Fishability’, and ‘Drinkability’. Swimmability means that all beaches are open and available for public swimming. Fishability means that all fish are safe for human consumption. Drinkability means that treated drinking water is safe for human consumption.

Chemical and microbial pollutants enter the human body through three major routes: ingestion (water, food, soil), inhalation (airborne), and dermal contact (skin exposure). Within the scope of the LaMP 2004 update, exposure to pollutants through water contact is highlighted. The major areas of health concern in the Great Lakes basin are pollutant exposure from ingestion of contaminated fish, incidental ingestion of water while swimming, and ingestion of contaminated drinking water.

5.1 LaMP 2002 TO 2004 ACCOMPLISHMENTS

5.1.1 Formation of the Great Lakes Human Health Network

The Lake Superior Workgroup took the initiative to recommend that the Binational Executive Committee (BEC) form a basin-wide Great Lakes Human Health network. As a result of the Workgroup’s efforts, the Great Lakes Human Health Network (Network) was established in December 2002. The Network, formed under the guidance of the BEC, has created a forum to discuss human health issues directly related to Great Lakes water quality. The Network addresses health issues related to the ecosystem of the Great Lakes basin, including drinking and recreational water quality and fish consumption.

The Network is a voluntary partnership of representatives of both U.S. and Canadian governments and their agencies whose purpose is to exchange information, facilitate communication, and support the coordination of public health and environmental agencies.

The Network holds regular conference calls to exchange information. The members transmit the shared information to their organizations and the communities they serve. The network also supports the LaMP and RAP processes.

Currently, the Network has representatives from six federal government agencies, five tribal government agencies, eleven state and provincial government agencies, and one county government agency. We anticipate that the membership will continue to grow as the Network becomes more widely known. Current information on the Network and its work may be found at www.epa.gov/glnpo/health.html.

5.1.2 Accomplishments/Activities Related to Fish Consumption Advisories and Contaminants in Fish

- States, tribes and the province of Ontario continue to provide advice to the public on making choices about which fish to eat and how often to reduce exposure to contaminants in fish. New outreach materials continue to be developed and distributed to the public, particularly targeted to women of childbearing age.

- As reported in the Chemical Chapter of this document, concentrations of routinely monitored contaminants such as PCBs, are declining in fish. U.S. EPA's Great Lakes National Program Office (GLNPO) Trend Monitoring Program recently began monitoring additional contaminants, such as polybrominated diphenylethers. The trends, human health exposure, and effects from these contaminants will continue to be assessed.

- Results from the Centers for Disease Control and Prevention (CDC) National Health and Nutrition Examination Survey (NHANES) 1999-2000 survey indicate that 8% of U.S. women of childbearing age may have exposures to methylmercury above a level that the U.S. EPA considers safe. Human exposure to methylmercury is mainly a result of fish consumption.

- The Wisconsin Environmental Public Health Tracking Collaborative (WEPHTC) is streamlining and centralizing access to existing environmental, agricultural, and health data systems specific to Wisconsin. This will create a user-friendly Wisconsin Public Health Tracking System. WEPHTC began a pilot project in January 2004 to examine the link between fish consumption and methylmercury exposure in men.

- The Lake Superior Binational Program sponsored a workshop in Thunder Bay in June 2003. Entitled "Mercury in Our Lives: A Workshop on Mercury reduction for the Lake Superior Community," the workshop was a resounding success. The workshop began with a presentation on human health issues including mercury in fish.

- The Great Lakes Indian Fish and Wildlife Commission presented a summary of chemical contamination in Lake Superior fish for the Great Lakes Fishery Commission State of Lake Superior Conference.

- The Food and Drug Administration (FDA) and U.S. EPA released a joint advisory on fish consumption and methylmercury. The revisions represented the first unified FDA and EPA revised advisory on fish consumption for populations at risk from exposure to high mercury levels (i.e., pregnant and nursing women, women of child-bearing age, and young children).

5.1.3 Accomplishments/Activities Related to Drinking Water

Water Quality Tracking -- A key action item in the 2002 Great Lakes Strategy stated that, "Beginning in 2002, the US Environmental Protection Agency (USEPA), in cooperation with local utilities, will track water quality at the intake points of selected drinking water treatment plants around the Lakes. Findings will be reported to the public through the biennial State of the Lakes Ecosystem Conference (SOLEC) State of the Lakes report." The web site may be found at http://www.epa.gov/glnpo/gls/gls04.html.

5.1.4 Accomplishments/Activities Related to Beaches Safe to Swim

Background. The Great Lakes Water Quality Agreement (IJC1994) calls for recreational waters to be substantially free from bacteria, fungi, and viruses. These microbial organisms of fecal origin have the potential to cause relatively mild illnesses (e.g., gastroenteritis) to more serious illnesses (e.g., hepatitis, typhoid fever) from a single exposure.

Lake Superior's myriad recreational activities do present opportunities for contamination to occur (i.e., swimming, water-skiing, sail-boarding, and wading). Apart from the risks of accidental injuries, the major human health concern for Lake Superior recreational waters is microbial contamination by bacteria, viruses, and protozoa (Health Canada, 1998; WHO, 1998).

To improve water quality testing at the beach and to help beach managers better inform the public when there are water quality problems, Congress passed the Beaches Environmental Assessment and Coastal Health Act (BEACH Act) in October 2000. U.S.EPA has established guidelines on the maximum level of pollution acceptable for fresh water use.

The BEACH Act authorizes U.S.EPA to award grants to eligible states, tribes, and territories to develop and implement beach water quality monitoring and public notification programs at coastal and Great Lakes beaches. These grants also support the development and implementation of programs to inform the public about the risk of exposure to disease-causing microorganisms in the waters at the Nation's beaches. This year, U.S.EPA awarded $9.9 million in grants to eligible states and territories for beach program implementation.

Progress on Developing and Implementing Beach Monitoring and Notification Plans. The Great Lakes Strategy calls for states to establish water quality monitoring and public notification programs that comply with the BEACH Act requirements at 95% of all high priority Great Lakes beaches. All of the Lake Superior states have beach monitoring and public notification programs in place at most of their coastal beaches.

Minnesota: In the 2003 season, 100% of Minnesota's beaches in the Lake Superior basin had beach monitoring and public notification programs in place.

Wisconsin: In the 2003 season, 100% of the high priority and medium priority Lake Superior beaches had monitoring and notification programs in place. Thirty-six percent of the low priority beaches are being monitored. Very small beaches with little or no use are not being tested.

Michigan: In the 2003 season, 59% of Michigan's beaches in the Great Lakes basin had beach monitoring and public notification programs in place.

Determine Pollutant Sources Linked to Beach Closings. The Great Lakes Strategy calls for States to evaluate Great Lakes beaches that are closed more than 5% of the swimming season to determine pollutant sources. States are beginning to identify pollution sources at their coastal beaches. U.S.EPA is working closely with the state beach programs coordinators to identify beaches affected by wet weather. U.S.EPA is developing a wet weather strategy to plan remediation efforts at these beaches.

Minnesota: At 12 beaches (out of 35), potential sources of pollution either on the beach or nearby have been identified. These sources are storm water discharges or streams with storm water discharges into them. The city of Duluth and the Western Lake Superior Sanitary District have conducted dye testing in the sewer lines and storm water pipe tanks to eliminate them as potential sources of bacteria at the New Duluth Boat Club site. They have also conducted a limited amount of spatial testing to determine if there is one specific point of discharge. The District has also been pursuing DNA fingerprinting. The sources of bacteria are as yet unknown but further investigation will take place this monitoring season.

Wisconsin: Many Lake Superior counties will begin to look at sources of pollution. Thus far, no sources have been identified.

Michigan: MDEQ is in the process of identifying the sources of contamination for all Great Lakes and inland beaches via its Total Maximum Daily Load (TMDL) program, its Combined Sewer Overflow (CSO) and Storm Sewer Overflow (SSO) Strategies, and local health department sanitary surveys.

Adoption of Bacteria Criteria that meet National Standards. As a requirement of accepting BEACH Act grants, states must adopt bacteria criteria at least as protective as U.S.EPA's published criteria at their coastal waters.

Minnesota: Minnesota currently monitors recreational waters for *E. coli* and will likely adopt U.S. EPA's bacteria criterion by 2005.

Wisconsin: Although Wisconsin currently monitors for *E. coli*, Wisconsin has not adopted U.S.EPA's bacteria criterion as the state's standard. Wisconsin is in the process of adopting U.S. EPA's bacteria criterion but it will probably not adopt the standard until 2005.

Michigan: Michigan has already adopted U.S.EPA's ambient water quality criterion for bacteria.

Meet Bacteria Standards at Great Lakes Beaches. The Great Lakes Strategy states that by 2010, 90% of monitored, high priority Great Lakes beaches will meet bacteria standards more than 95% of the swimming season.

Minnesota: During the 2003 swimming season, 89% of Minnesota beaches in the Lake Superior basin met bacteria standards more than 95% of the time.

Wisconsin: During the 2003 swimming season, 45% of monitored beaches met bacteria standards more than 95% of the time. (Data include both Lake Superior and Lake Michigan beaches.)

Michigan: During the 2003 swimming season, 73% of Michigan's beaches in the Great Lakes basin met bacteria standards more than 95% of the time.

5.1.5 Accomplishments Related to Communication to the Public

Because it has been shown that people who engage in recreational water sports have a higher incidence of symptomatic illnesses, it has become increasingly more important to make the public aware of the potential health hazards that are associated with recreational waters. Recent progress has been made on the national and local levels to provide the public with useful tools that can provide needed information regarding the use of recreational waters.

- BEACHNET. Provides the opportunity for interested citizens to improve recreational beach water quality in the Great Lakes Basin through networking, collaboration, and information exchange. BEACHNET is sponsored by the Great Lakes Beach Association and brings together members from federal, state, county and local agencies, public health agencies, regulatory agencies, researchers, universities, and environmental groups from Ohio, Michigan, Indiana, Illinois, Wisconsin, Minnesota, New York, Pennsylvania, and Environment Canada. (http://www.great-lakes.net/glba)

- BeachCast. Provides Great Lakes beach goers with access to information on Great Lakes beach conditions, including health advisories, water temperature, wave heights, monitoring data, and more. BeachCast is a service of the Great Lakes Commission and its Great Lakes Information Network (GLIN) (http://www.glc.org/announce/03/07beachcast.html).
- EMPACT. The National Risk Management Research Laboratory of U.S.EPA's Office of Research and Development initiated the development of this handbook to help interested communities learn more about the beach monitoring projects associated with U.S.EPA's Environmental Monitoring for Public Access and Community Tracking (EMPACT) Program and to give communities the information they need to conduct their own projects http://www.epa.gov/ORD/NRMRL/Pubs/625R02017/625R02017.pdf).
- BEACH Watch. Contains information about U.S.EPA's BEACH Program, links to local beach protection programs, and access to U.S.EPA's national beach water quality database. Provides up-to-date information on beach health protection activities around the country (http://www.epa.gov/waterscience/beaches/).

5.2 CHALLENGES AND NEXT STEPS FOR 2004 TO 2006

- Health Canada will formalize their Canadian Great Lakes Human Health Network in Spring 2004;
- Canadian and U.S. Great Lakes Human Health Network will merge in 2004; and
- The Binational Network will develop workplans for 2004 and/or 2005.

5.3 INFORMATION

Web links listed below provide reference material for information cited in beach LaMP updates. In addition, a collection of useful resources has been compiled for future use.

Government Action to Protect the Public Health

Monitoring
http://www.epa.gov/waterscience/beaches/local/sum2.html
http://www.epa.gov/waterscience/beaches/grants/2003/fs.htm
http://www.epa.gov/waterscience/beaches/about.html

Research
http://www.epa.gov/nerlcwww/neearnerl.htm

Communication Outreach

http://www.great-lakes.net/lists/beachnet/beachnet.info
http://www.glc.org/announce/03/07beachcast.html
http://www.epa.gov/ORD/NRMRL/Pubs/625R02017/625R02017.pdf
http://www.epa.gov/glnpo/lakemich/lmlamp2000/LM%20chapter%204.pdf

Source Reduction
http://www.southholland.org/Tarp_Plan.htm
http://www.mmsd.com/tunnelfactsheet.html
http://cfpub1.epa.gov/npdes/home.cfm?program_id=5
http://www.great-lakes.net/humanhealth/lake/
http://www.rougeriver.com/cso/index.html#Summary

Emerging Issues
http://www.epa.gov/region5/water/pdf/factsheets/R4_G3_RecreationalWQ.pdf
http://www.epa.gov/ORD/WebPubs/beaches/
http://www.zwire.com/site/news.cfm?newsid=10320818&BRD=988&PAG=461&dept_id=141265&rfi=8

Resource Information
Great Lakes BeachCast - http://www.great-lakes.net/beachcast/nr.html
EPA's BEACH Watch website - http://www.epa.gov/waterscience/beaches/
EPA BEACH Act - http://www.epa.gov/waterscience/beaches/act.html

NRDC "Testing the Waters 2003" survey - http://www.epa.gov/waterscience/beaches/act.html

EPA's Great Lakes Strategy 2002 - A plan for the new Millennium - http://www.epa.gov/glnpo/gls/gls04.html

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EPA. 2003. Great Lakes Strategy 2002. http://www.epa.gov/glnpo/gls/gls04.html
EPA. 2003. Lake by Lake: Lake Erie. http://www.great-lakes.net/humanhealth/lake/
EPA. 2003. The National Epidemiological and Environmental Assessment of Recreational (NEEAR) Water Study: Water Quality. http://www.epa.gov/nheerl/neear/index.html
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EPA. 2003. Time-Relevant Beach and Recreational Water Quality Monitoring and Reporting. http://www.epa.gov/ORD/NRMRL/Pubs/625R02017/625R02017.pdf
EPA. 2003. Water Indicator Fact Sheet. http://www.epa.gov/region5/water/pdf/factsheets/R4_G3_RecreationalWQ.pdf
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Chapter 5

Human Health

Fishing along Lake Superior
Photograph by: Lake County Forest Preserve District

Lake Superior Lakewide Management Plan
2000

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EXECUTIVE SUMMARY

Purpose

The 1987 Protocol to the Great Lakes Water Quality Agreement (GLWQA) states that Lakewide Management Plans for open lake waters shall include "A definition of the threat to human health or aquatic life posed by Critical Pollutants." The goal of the human health chapter of the Lake Superior LaMP 2000 is to fulfill the human health requirements of the GLWQA, including describing the potential adverse human health effects arising from exposure to persistent, bioaccumulative, toxic chemicals (PBT chemicals) as well as other contaminants of health concern (including microbial contaminants) in the Lake Superior basin.

What's Included

The human health chapter for the Lake Superior LaMP has:
- identified potential human health implications from contaminants in the Lake Superior environment;
- discussed current programs and strategies designed to protect human health;
- developed an action plan to continue to protect human health; and
- proposes a suite of human health related indicators.

Background

Exposure to environmental contaminants through recreational water use, air, soil, and food consumption are discussed in detail, with particular emphasis on the existing evidence for human health effects from exposure to PBT chemicals through food, especially consumption of Great Lakes fish.

Microbial contamination of drinking water can pose a potential public health risk in terms of acute outbreaks of disease. Gastro-intestinal disorders and minor skin, eye, ear, nose and throat infections have been associated with microbial contamination of recreational waters.

Demonstrating health effects in humans from chronic, low-level exposure to PBT chemicals typically encountered in the Great Lakes region poses a challenge for researchers. For example, human epidemiological studies are limited in their ability to separate health effects attributable to contaminant exposures from those related to other known health factors like smoking, alcohol intake and general health status. Despite these limits, neurodevelopmental and reproductive effects have been reported in some studies of human populations in the Great Lakes basin. In addition, developmental effects have been observed in wildlife and laboratory studies of PBT chemicals. Therefore, in defining the threat to human health from exposure to contaminants in the Lake Superior basin, a weight of evidence approach is often used, where the overall evidence from wildlife studies, experimental animal studies, and human studies is considered. These human and wildlife studies are sufficient to suggest that human health is at risk from exposure to PBT chemicals, and may have profound implications for the population.

Conclusions

Progress continues to be made to reduce the risk to health from exposure to environmental contaminants in the Great Lakes basin. Since the 1970's, there have been steady declines in many PBT chemicals in the Great Lakes basin, leading to declines in levels in human tissues, for example, lead in blood, and organochlorine contaminants in breast milk. This translates into a reduced risk to health for these contaminants.

The following are the specific conclusions from the paper:

- Drinking water is generally of good quality but continued efforts towards the detection and treatment of microbial contaminants is important to reduce risk of acute water borne disease.
- Although it not possible to document the risk to health from contaminants in recreational water quality, exposure levels of health concern have been documented in the Lake Superior basin.
- While the average person within the Lake Superior basin does not eat enough fish and wildlife to pose a risk to their health, there are some people who do. People who eat a lot of fish, regularly eat large predator fish, eat fish from highly contaminated waters, or eat a lot of fish over a short period of time are at increased risk of exposure and health effects. In addition the developing fetus and young children are at greater risk than adults. Although fish consumption programs are well established in the basin, studies show that only half of the population are aware of these advisories.
- For the Lake Superior basin the current weight of evidence regarding human health effects is sufficient to support the continued reductions in the levels of PBT chemicals in the environment.

Actions

To protect human health, actions must continue to be implemented on a number of levels. Reductions and monitoring of contaminant levels in environmental media and in human tissues is an activity in particular need of support. Health risk communication is also a crucial component to protecting and promoting human health in the Lake Superior basin. The LaMP can play a key role in informing people about human health impacts of environmental contaminants and what they can do to minimize their health risks. This includes linking people to information that is packaged in a variety of ways and targeted to a range of audiences, to enable people to make informed choices about their health.

The four priority areas of activity for human health, further elaborated on in the Implementation Plan/Action Matrix presented in Section 5.5 of the chapter, are:

- continued reduction of contaminants to the Lake Superior ecosystem (virtual elimination, beginning with the zero discharge demonstration program)
- monitoring contaminant levels in the environment and in human tissue to help determine extent of exposure;
- support the continued research into the linkages between environmental contaminants and human health outcomes; and
- communicating health risks and how to minimize them.

After the release of the LaMP 2000 document in April, several actions will be taken to continue progress toward reducing the risk to human health from exposure to environmental contaminants. Figure 5-1 is a summary of human health actions, the lead agency for implementation, and the funding status.

Figure 5-1. Action Summary

Project	Lead Agency/ Funding Source	Funded	Needs Funding
Improve Effectiveness of Fish Consumption Advisories for Mercury Contaminated Sport Fish Project	WI and ME - U.S. EPA funded	X	
Increase Awareness of Great Lakes Fish Consumption Advisories among Women of Childbearing Age	Great Lakes States - ATSDR funded	X	
Fish Consumption Study	GLIFWC	X	
Qualitative Risk/Benefit Analysis of Fish Consumption	U.S. EPA OST	X	
Preparation and Implementation of Protection Plans for Water Supply Intakes on Lake Superior	Great Lakes States and U.S. EPA	X	
Analysis of mercury in hair from MN Lake Superior basin residents			X
Screen fish from U.S. Lake Superior Basin for suite of OCCs - as PCBs decline other OCCs will become an issue			X
Literature review of wildlife consumption issues			X
Quantitative Risk/Benefit analysis of fish consumption			X
Need a better understanding of the chemical reactions and interactions in the transition zone between groundwater and surface water, to facilitate quantitative risk assessment of the potential effects of PBT contaminated sediments.			X
Promote the use of E. Coli testing and methods over fecal coliform (training video distribution).	U.S. EPA	X	
Promote beach monitoring programs in areas where they do not exist.			X
Promote reporting of results to the U.S. EPA BEACHs Program.			X
Promote the communication of risks (advisories and closures) to the public.			X
Water Quality Indicators Research: Cost effective real time monitoring/assessment methods need to be developed.			X
Development of effective modeling/monitoring to better estimate/predict beach/water exceedences.	U.S. EPA, Health Canada	X	
Exposure and health effects research: epidemiological research into the relationships between beach/water indicators and health outcomes. Research on the interstitial zone.	U.S. EPA, USGS, Health Canada	X	

Figure 5-1. Action Summary

Project	Lead Agency/ Funding Source	Funded	Needs Funding
EPA will be developing policies to ensure that states and tribes adopt the currently recommended *Ambient Water Quality Criteria for Bacteria - 1986* and make the transition to monitoring for E. coli and enterococci indicators rather than total coliforms or fecal coliforms.	U.S. EPA	X	
EPA will also develop a national inventory of digitized beach maps which will be linked with locations of pollution sources through a Geographic Information System.	U.S. EPA	X	
EPA is proposed to conduct research to determine pathogen occurrence and indicator relationships associated with wet weather flows.	U.S. EPA	X	
U.S. EPA is developing and supporting efforts related to the protection of recreational waters, which may include training in new methods, other technology transfer opportunities, and guidance implementation. The EPA is currently in the process of developing National Guidance for Recreational Beach Managers, which will be used as a guidance tool for public health officials and other recreational water quality monitoring officials to reduce the risk of disease to users of recreational waters through improvements in water monitoring and public notification programs. A training video for Recreational Beach Managers is expected to be completed and distributed by mid-year, 2000.	U.S. EPA	X	

5.0 ABOUT THIS CHAPTER

There is concern about the effects that Great Lakes contaminants, and in particular persistent, bioaccumulative toxic chemicals (PBT chemicals), have on human health. The Revised Great Lakes Water Quality Agreement of 1978 (GLWQA), as amended by Protocol signed November 18, 1987, states that Lakewide Management Plans (LaMPs) for open waters shall include “A definition of the threat to human health or aquatic life posed by Critical Pollutants”. The goal of the Lake Superior LaMP Human Health chapter is to fulfill the human health requirements of the GLWQA, including:

- to define the threat to human health and describe the potential adverse human health effects arising from exposure to Critical Pollutants and other contaminants (including microbial contaminants) found in the Lake Superior basin;
- to address current and emerging human health issues of relevance to the LaMP; and
- to identify implementation strategies currently being undertaken to protect human health and suggest additional implementation strategies that would enhance the protection of human health.

The World Health Organization defines human health as “a state of complete physical, mental and social well-being, and not merely the absence of disease ...” (World Health Organization 1984). Therefore, when considering human health, all aspects of well-being need to be considered, including physical, social, emotional, spiritual, and environmental impacts on health.

Human health is influenced by a range of factors, such as the physical environment (including environmental contaminants), heredity, lifestyle (smoking, drinking, diet and exercise), occupation, the social and economic environment the person lives in, or combinations of these factors. Exposure to environmental contaminants are one among many factors that contribute to the state of our health (Health Canada 1997). It is important to consider the complete range of factors that influence health, and the complex interactions between these factors, when investigating the role of environmental contaminants as a causal factor in health outcomes .

Consideration of human health in the Lake Superior basin must also take into account the diversity of the Lake Superior basin population, which includes a range of cultural groups including aboriginal peoples. Certain subpopulations, such as high fish consumers, may have higher exposures to persistent toxic chemicals than the general population, and therefore may be at increased risk of suffering adverse health effects. In addition, some exposed subpopulations, such as the elderly, women and men of child-bearing age, the fetus, nursing infants, children, and the immunologically compromised, may be more susceptible to the effects of PBT chemicals (Johnson and others 1998, Health Canada 1998d). Therefore, the discussion of health issues in this chapter looks at the health of the general population as well as subpopulations at increased risk of exposure and health effects.

The Native American/aboriginal populations in the Great Lakes basin represents an important population at increased risk of exposure to environmental contaminants, and therefore may be at increased risk of suffering adverse effects. Higher exposures in these populations are the result of the strong cultural relationship between those populations and their environment. Spiritual, medicinal, hunting, gathering and fishing traditions increase the number of exposure routes for this population. For example, Native Americans in the Great Lakes have much higher fish consumption rates than those accounted for by current methods used to devise water quality criteria. Also, Native Americans in the region harvest other natural resources that are potential sources of exposure, including the consumption of deer livers and wild rice. Both of these represent additional routes of exposure to trace heavy metals (such as cadmium) that are known to accumulate in wild rice and livers of deer.

Of the several hundred environmental contaminants found in the Great Lakes basin, the International Joint Commission (IJC) has identified eleven chemicals (designated as “Critical Pollutants”) to be of greatest concern because they are persistent in the environment and bioaccumulate in the food chain. Food, in particular the consumption of Great Lakes fish, is the primary route of human exposure to these PBT chemicals. The nine chemicals designated for zero discharge demonstration for Lake Superior (see Chapter 4 for list) are a subset of the eleven Great Lakes Critical Pollutants identified by the IJC. These chemicals have caused developmental defects, cancer, and other chronic diseases in laboratory animals, fish, and wildlife (Health Canada 1998d). This has raised concern about their effects on human health, and research is focused on quantifying human exposure and determining health effects, particularly in sub-populations such as high fish consumers.

Demonstrating health effects in humans from chronic, low-level exposure to PBT chemicals typically encountered in the Great Lakes region poses a challenge for researchers. For example, human epidemiological studies are limited in their ability to separate health effects attributable to contaminant exposures from those related to other known health factors like smoking, alcohol intake and general health status. Despite these limits, neurodevelopmental and reproductive effects have been reported in some studies of human populations in the Great Lakes basin. In addition, developmental effects have been observed in wildlife and laboratory studies of PBT chemicals. Therefore, in defining the threat to human health from exposure to contaminants in the Lake Superior basin, a weight of evidence approach is often used, where the overall evidence from wildlife studies, experimental animal studies, and human studies is considered. These human and wildlife studies are sufficient to suggest that human health is at risk from exposure to PBT chemicals, and may have profound implications for the population.

Descriptions of the nine zero discharge chemicals can be found at http://www.cciw.ca/glimr/lamps/lake-superior/ . In addition, detailed toxicological profiles describing the health effects of these chemicals have been published by the U.S. Agency for Toxic Substances and Diseases Registry (ATSDR; see list of titles under Section 5.7 of this Chapter - "Internet Information Resources and Further Reading Lake Superior Human Health Issues").

Since the 1970s, there have been steady declines in many PBT chemicals in the Great Lakes basin, leading to declines in levels in human tissues -- lead in blood, and organochlorine contaminants in breast milk. For example, composite levels of seven persistent organochlorine pesticides (including DDT and its metabolites, dieldrin, oxychlordane [a metabolite of chlordane] and HCB) in human breast milk in Canada have declined 80 percent since 1975 (Craan and Haines 1998). This translates into a reduced risk to health for these contaminants. However, PBT chemicals, because of their ability to bioaccumulate and persist in the environment, continue to be a significant concern in the Lake Superior basin. Therefore, remediation and pollution prevention measures to continue to reduce contaminant levels in the Lake Superior basin should be continued, while at the same time public health advisories and other guidelines should be followed to protect human health from current environmental exposures.

Section 5.1 of this chapter describes the pathways of exposure relevant to human health and also provides information on the status for Lake Superior, public health protections in place and needs for the future for drinking water, recreational water, air pollution, soils/sediments and fish/food consumption; Section 5.2 explains and applies a weight of evidence approach to looking at potential health effects from PBT chemicals and identifies futures research needs; Section 5.3 describes proposed indicators of human health; Section 5.4 provides an overall conclusion and recommended actions to be taken to protect human health; Section 5.5 is a glossary of terms for this Chapter; Section 5.6 lists Lake Superior relevant human health Internet resources; and Section 5.7 contains the references for this Chapter.

5.1 EXPOSURE PATHWAYS AND RELEVANT HUMAN HEALTH ISSUES

The three major routes that chemical and microbial pollutants enter the human body are by ingestion (water, food, and also soil - particularly in the case of children), inhalation (airborne), and dermal contact (skin exposure). In addition, the long-range transport of PBT chemicals is a major source of deposition to the Lake Superior basin. Although it is not a pathway of direct human exposure to persistent contaminants, long-range transport represents an indirect exposure because it provides a significant source for contaminants that accumulate and magnify in the Lake Superior basin food chain.

The Critical Pollutants and Prevention Pollutants for Lake Superior include organochlorines such as PCBs and toxaphene, and metals such as lead and mercury (for a complete pollutants list for the Lake Superior basin see Lake Superior LaMP Stage 2: Load Reduction Targets for Critical Pollutants 1998). These chemicals do not break down easily, tend to persist in the environment, and bioaccumulate in biota and animal and human tissues -- thus they are called Persistent Bioaccumulative Toxic chemicals (PBT chemicals). Organochlorines tend to accumulate in fat (such as adipose tissue and breast milk), and metals tend to accumulate in organs and flesh. The major route of exposure for these PBT chemicals is through food, including fish consumption (Health Canada 1998e, Johnson and others 1998). Sources from air, soil/dust, and water, including the lakes themselves, constitute a minor route of exposure (Health Canada 1998e). Most of the health effects studies for Great Lakes PBT chemicals have focused on fish consumption. These studies are discussed in Section 5.2 of this Chapter.

The human health ecosystem objectives developed for the Lake Superior LaMP are related to the exposure pathways identified above, and are outlined in Table 5-1.

Table 5-1 Health Related Ecosystem Objectives for Lake Superior LaMP and Pathways of Exposure

Ecosystem Objective	Pathway of Exposure	Contaminant of Primary concern
Overall Human Health Objective: The health of humans in the Lake Superior ecosystem should not be at risk from contaminants of human origin.		
Fish and wildlife in Lake Superior ecosystem should be safe to eat; consumption should not be limited by contaminants of human origin.	Food/fish consumption	PBT chemicals i.e. organochlorines, methylmercury
Water quality in Lake Superior should be protected where it is currently high, and improved where it is degraded. Surface waters and groundwater should be safe to drink after treatment to remove natural impurities and micro-organisms.	Drinking water (includes water used for cooking, and used in preparation of beverages)	microbial contaminants (primary health concern); chemicals such as aluminum, nitrates
The waters of Lake Superior should be safe for total body contact activities, even adjacent to urban and industrial areas.	Recreational water use that involves total body contact with water (incidental ingestion, dermal contact, inhalation)	microbial (primary health concern); chemicals such as PAHs.
Air quality in the Lake Superior ecosystem should be protected where it is currently high, and improved where it is degraded. Communities, industries and regulators outside the Lake Superior ecosystem should be informed of the consequences of long-range atmospheric transport of contaminants into the Lake Superior basin.	Direct inhalation, and also atmospheric deposition and subsequent bioaccumulation of PBT chemicals through the food chain	Inhalation: Chemicals such as ozone, sulphates, acidic air pollutants, particles; Atmospheric deposition: PBT chemicals
Soils in the Lake Superior ecosystem should not present a hazard to human health through direct contact, dust inhalation or ingestion, groundwater contamination, or crop contamination	Ingestion of soils; Sediments - indirect exposure through food chain	PBT chemicals i.e. organochlorines, methyl mercury

Exposure to compounds in different types of environmental media (e.g. air, soil, groundwater...) may be expected to have different effects or to affect humans with different levels of severity. For example, chromium IV (chromium with a charge of +6) is a potent carcinogen when inhaled from air and yet it has been shown to change chemically when ingested, in the gastro-intestinal (GI) tract, to relatively non-toxic chromium III (chromium with a charge of +3). Furthermore, the likelihood of exposure may be different for chemicals in different media. Lead in grass covered soil is unlikely to be ingested by anyone except a pica (soil eating) child, yet lead in dust or unvegetated soil may stick to skin, be inhaled, or be ingested with food. Many compounds when found in surface waters may compromise the health of aquatic organisms, but are not expected to impact humans. Depending on the chemical contaminant or ambient concentration in the water, this may be because aquatic organisms live enveloped in surface waters, or because people do not typically drink untreated surface waters. While exposure to some compounds in turbid or agitated water, like PAHs, can cause irritation of the skin or, potentially, other adverse human health effects, these levels of contamination will typically kill or severely restrict populations of aquatic organisms, especially benthic organisms.

5.1.1 Environmental Contaminants in Lake Superior Basin Drinking Water

Access to clean drinking water is essential to good health. The waters of Lake Superior and surrounding areas are a primary source of drinking water for the people who live in the Lake Superior basin. The Great Lakes Water Quality Agreement designates “restrictions on drinking water consumption, or taste and odour problems” as an impaired beneficial use -- note that “taste and odor” is an aesthetic impairment as opposed to a health-related impairment (IJC, Annex 2.1.c. 1987).

While there has been an overall reduction of contaminants in the Great Lakes basin since the 1970s, contamination of the lakes through human activity continues to be of public and scientific concern. Since the most common way for people to be exposed to contaminants in water in the Great Lakes basin is through the drinking water supply, the potential health effects are of particular importance (Health Canada 1995a).

The province of Ontario, and three U.S. states, Michigan, Minnesota and Wisconsin, border Lake Superior, and although many of the communities within the basin are sparsely populated, approximately 650,000 residents on the U.S. side and upwards of 200,000 residents (including 130,000 on communal water) on the Canadian side of the Lake Superior basin use basin water for drinking, cooking, bathing, and other household uses. This water is obtained from a variety of suppliers, both public and private. Public suppliers provide water which is drawn from either surface water sources (including Lake Superior and/or surrounding waters), groundwater sources, or from a combination of these sources. For private suppliers, a large portion of permanent and seasonal residents use private water supply systems, water is drawn from wells or surface water sources (Health Canada 1998b).

In Minnesota and Wisconsin, the communities that draw their drinking water directly from Lake Superior are Grand Portage, Grand Marais, Silver Bay, Beaver Bay, Two Harbors, Duluth, (Cloquet uses Lake Superior as a backup water supply), Ashland and Superior. Michigan communities which use Lake Superior as a drinking water source are Marquette, Baraga, L'Anse and Sault Ste. Marie. In Ontario, communities that draw their drinking water directly from Lake Superior include Rossport, Terrace Bay, and Thunder Bay. (Thunder Bay has two treatment facilities, one drawing its water from Lake Superior [Bare Point Water Treatment Plant], and the other drawing its water from Loch Lomond, an inland lake). The remaining communities within the Lake Superior basin use inland lakes or rivers (surface water) and/or groundwater to supply drinking water. At present none of the eight Areas of Concern (AOC) in the Lake Superior basin list restrictions on drinking water as a use impairment in their Remedial Action Plans (for more information on Lake Superior AOCs go to: http://www.cciw.ca/glimr/raps/intro.html)

A variety of contaminants can adversely impact drinking water, including micro-organisms (e.g. bacteria, viruses, and protozoa such as Cryptosporidium), chemical contaminants (including naturally occurring chemicals and anthropogenic [synthetic] chemicals), and radiological contaminants -- including naturally-occurring inorganic and radioactive materials (IJC 1996, Health Canada 1997, Lake Erie LaMP 1999, OME 1999). Some contaminants of raw water supplies, such as aluminum, arsenic, copper, and lead, can be both naturally occurring and/or result from human activities. Other contaminants, such as household chemicals, industrial products, urban storm water runoff, fertilizers, human and animal waste, nitrate (from fertilizers and sewage), and pesticides may also end up in raw water supplies (U.S. EPA 1999f, Health Canada 1998b).

Some individuals or groups, particularly children and the elderly, may be more sensitive to contaminants in drinking water than the average person (Health Canada 1993). Although drinking water quality guidelines are for the general population, they are based on health effects observed in the most sensitive subgroup of the population (e.g. lead and children).

5.1.1.1 Microbial Contaminants

Microbial contamination of drinking water can pose a potential public health risk in terms of acute outbreaks of disease. The illnesses associated with contaminated drinking water are mainly of a gastro-intestinal nature, although some pathogens are capable of causing severe and life-threatening illness (Health Canada 1995a). In most communities, drinking water is treated to remove contaminants before being piped to consumers, and microbial contamination of municipal water supplies has been largely eliminated by adding chlorine or other disinfectants to drinking water to prevent waterborne disease. By treating drinking water, we have virtually eliminated diseases such as typhoid and cholera. Although other disinfectants are available, chlorine still tends to be the treatment of choice. When used with multiple barrier systems (i.e. coagulation, flocculation, sedimentation, filtration), chlorine is effective against virtually all infective agents. (U.S. EPA/Government of Canada 1995; Health Canada 1993, 1997, and 1998).

In Canada and the U.S., community water suppliers deliver high quality drinking water to millions of people every day, and a network of government agencies are in place to ensure the safety of public drinking water supplies (OGWDW 1999a) But although our drinking water is safer today than ever, problems can, and do, occur, although they are relatively rare. Localized outbreaks of water-borne disease have been linked to contamination by bacteria or viruses, probably from human or animal waste (U.S. EPA 1999f).

Recently, there has been increasing concern over the presence in drinking water of parasites such as Giardia and Cryptosporidium (the most common source of which is animal feces), which are resistant to common disinfection practices, and may pass through water treatment filtration and disinfection processes in sufficient numbers to cause health problems (Health Canada 1998a). For example, in 1993, Milwaukee, Wisconsin experienced a widespread outbreak of cryptosporidiosis that affected over 400,000 residents, causing severe diarrhea, nausea, stomach cramps, and other symptoms. While most people recovered without treatment, the outbreak contributed to the deaths of at least 100 people already ill with AIDS-related illnesses, cancer or other maladies. The outbreak was caused by Cryptosporidium oocysts that passed through the filtration system of one of the city's two water-treatment plants (WI DNR 1994, WI DNR 1998, Health Canada 1997).

Thunder Bay Drinking Water Case Study

In October 1997, the Medical Officer of Health for the Thunder Bay District Health Unit issued a Boil Water Advisory to the residents of the south side of the city of Thunder Bay following the receipt of a laboratory report confirming the presence of Giardia in the water distribution system. The cyst was found on routine testing in the post-treated water supply in the south section of the city. In consultation with the Ministry of Health, Ministry of Environment, and city officials it was agreed that due to lack of a barrier filtration system, the advisory was made to inform the public who were supplied by the compromised system to a potential threat of water-borne disease.

During the 13 months of the Boil Water Advisory, the city undertook the installation of a temporary filtration plant to ensure that water from its Loch Lomond site was safe for its consumers. Once completed, and having met the minimum requirements of the Ministry of the Environment, the Boil Water Advisory was lifted on November 8, 1998. Plans by the city are underway to expand its water treatment facilities in the north end of the city to provide filtered treated water to the entire city from one source.

Boiling water is the best method for killing Cryptosporidium and bacteria in emergency situations (Health Canada 1997) and boil water orders are generally the standard public health protection method when drinking water is found to be contaminated. Since the Milwaukee outbreak, U.S. EPA has strengthened treatment requirements and standards for public water supplies using surface water. Health Canada, in collaboration with the provinces, is currently developing a drinking water guideline for Giardia and Cryptosporidium, is reviewing its turbidity guideline, and recently published a document titled "Guidance for Issuing and Rescinding Boil Water Advisories" (November 1998, revised March 1999), as a tool for health and environment authorities who must make the decisions concerning boil water advisories. These guideline documents can be found at Health Canada's web site at: http://www.hc-sc.gc.ca/ehp/ehd/catalogue/bch_pubs/dwgsup_doc.htm

5.1.1.2 Chemical Contaminants

Certain chemical contaminants are of concern in drinking water because of possible health concerns associated with exposure to these substances. These contaminants may be in the raw (untreated) water as a result of industrial and agricultural activities, or treated wastewater discharges (MPCA 1997). Some may also be present in the treated water as a result of chemicals used in the drinking water treatment process (Health Canada 1998b). A snapshot of some chemical contaminants of concern (including aluminum, chlorination disinfection by-products, and contaminants in groundwater) is presented below.

Food, including fish consumption, is the primary route of exposure to PBT chemicals, including the nine chemicals designated as zero discharge contaminants for Lake Superior. Previous assessments for the Canadian Great Lakes basin (Health Canada 1998b) show the intake of PBT chemicals via drinking water is negligible (less than 1 percent of total intake from all sources). They are well below the Maximum Acceptable Concentration (MAC) listed in the Ontario Drinking Water Objectives (OME 1994) and the Guidelines for Canadian Drinking Water Quality (sixth edition, Health Canada 1996). For the U.S. Great Lakes basin including Lake Superior, measured levels of these persistent toxic chemicals in drinking water are below the Maximum Contaminant Levels (MCLs) in Lake Superior, and therefore they are not considered to be a human health concern for drinking water. (Personal communication Doug Mandy, Minnesota Department of Health, 2000).

Public water systems use various processes in order to treat raw water. One process involves the addition of alum, an aluminum compound that is used for the coagulation of suspended solids. Subsequently, the use of alum in the treatment process can raise the levels of aluminum in drinking water if the process is not optimized. If the quality of the raw water is poor, it may affect the amount of aluminum that needs to be added. There is much debate as to the role aluminum may play in the development of Alzheimer’s Disease and other dementias (Health Canada 1997, Health Canada 1998b).

Currently, the U.S. EPA does not regulate aluminum under its drinking water program but has a secondary, non enforceable standard of 50-200 µg/l (this number is based on organoleptic properties). The U.S. EPA is working to determine if aluminum is of health concern and has placed aluminum on its Contaminated Candidates List (CCL). This list is the source of priority contaminants for the Agency’s drinking water program. Priorities for drinking water research, occurrence monitoring, guidance development, including the development of health advisories will be drawn from the CCL. The CCL also serves as the list of contaminants from which the Agency will decide whether of not to regulate specific contaminants.

Other processes commonly used by water treatment plants include the addition of disinfectants such as chlorine to inactivate or kill micro-organisms in the distribution system. However, chlorine and other disinfectants can combine with naturally occurring organic matter in the raw water to produce disinfection byproducts. Of the chlorination disinfection byproducts, trihalomethanes (THMs) are present in the highest quantities. Evidence from toxicologic and epidemiologic studies suggests a possible link between byproducts of the chlorination process and increased risk of some cancers (e.g., bladder and colon) and adverse pregnancy outcomes (e.g., miscarriage, birth defects and low birth weight). The amount of chlorination required and resulting levels of chlorination disinfection byproducts are dependent upon the quality of the raw water, including microbiological quality and organic content (Health Canada 1995a, 1997). Zebra mussel control at drinking water intakes can also result in increased levels of disinfectants and disinfection byproducts in finished drinking water. Nutrient enrichment in source waters can cause algal blooms which contribute to total organic carbon levels. In the U.S., EPA is developing standards to address the issue of disinfectants and disinfection-by-products. In Canada, Health Canada re-opened the THMs guideline in April 1998 and established a multi-stakeholder Task Group to oversee a comprehensive update of health risk information on THMs and to develop recommendations for controlling the risks.

Some materials in soils are naturally-present (example arsenic, mercury) and can become dissolved or suspended in groundwater. Groundwater can also pick up materials of human origin that have been spilled or buried in dumps and landfill sites, or that have resulted from agricultural activities (example nitrates, atrazine). Contamination can therefore occur both in urban/industrial areas, and in rural/agricultural areas (U.S. EPA 1995, Health Canada 1998b).

5.1.1.3 Protecting Public Health - Regulation of Drinking Water

United States

The U.S. EPA's Office of Groundwater and Drinking Water (OGWDW) plays a key role with respect to drinking water in the U.S.A. Its mission is, "OGWDW, together with states, tribes, and other partners, will protect public health by ensuring safe drinking water and protecting ground water" (U.S. EPA 1999f). The information that follows is taken from the OGWDW, and its web site at http://www.epa.gov/OGWDW/. This web site provides detailed information on the nation's drinking water, including drinking water and health, drinking water standards and local drinking water information.

The U.S. EPA has established legally enforceable standards for public water systems called National Primary Drinking Water Regulations (NPDWR). These standards are used to protect the quality of drinking water by limiting levels of contaminants in public water systems that can adversely affect public health (Federal Register 1998). Public water systems are required to monitor drinking water for a host of contaminants to ensure consumer safety. Frequency of monitoring in the U.S. is dependent on the type of system, whether the source water is surface or groundwater, the type of contaminant, whether or not a contaminant has been previously detected or has exceeded the standard, and the number of people served by the public water system.

Currently, the U.S. EPA does not regulate aluminum under its drinking water program but has a secondary, non enforceable standard of 50-200 μg/l (this number is based on organoleptic properties). The U.S. EPA is working to determine if aluminum is of health concern and has placed aluminum on its Contaminated Candidates List (CCL). This list is the source of priority contaminants for the Agency's drinking water program. Priorities for drinking water research, occurrence monitoring, guidance development, including the development of health advisories will be drawn from the CCL. The CCL also serves as the list of contaminants from which the Agency will decide whether of not to regulate specific contaminants.

The U.S. EPA requires public water systems to be monitored for bacteriological, inorganic, organic and radiological contaminants. Monitoring of drinking water includes physical and chemical characteristics of the water, as well as analysis for contaminants resulting from natural sources or human activities.

Information on local water quality is available from several sources, including the state public health department and local water supplier. To inform the public of the results of the chemical analyses of drinking water and to demonstrate a commitment to protect human health, the U.S. EPA requires each community water system to generate an annual Consumer Confidence Report that is made available to all residents receiving water from that water system. Consumer Confidence Reports provide information about the source of water used, its susceptibility to contaminants where a source water assessment has been completed, the levels of contaminants detected in the water, the likely source(s) of contaminants, and potential health effects of any contaminant detected above that specific Maximum Contaminant Level (MCL). Copies of Consumer Confidence Reports exist at the state and county level, and can be reviewed to give an indication of overall quality of treated surface water and groundwater, and the condition of the drinking water service.

Each state also has a department that regulates drinking water systems, and these agencies can also provide information about the local water supply and its quality. In addition, the U.S. EPA maintains a data base which contains information on individual ownership, locations, violations, and enforcement actions (U.S. EPA 1999a). Most state drinking water databases include system detection information.

Source water assessments - States are required to prepare source water assessments for all public water supply systems by May, 2003. An assessment must contain - 1) designation of a source water area, 2) identification of the contaminants of concern to the users of the water supply, and 3) locations of potential contamination sources to the extent this is practical.

Wellhead Protection - Public water suppliers will be required to prepare and implement wellhead protection plans under provisions of Minnesota's wellhead protection rule. The goal is to have all community and nontransient, noncommunity water supplies that have vulnerable wells phased into the wellhead protection program by May, 2003. Wellhead protection plans are voluntary in Michigan and in Wisconsin that are required for some types of public systems.

Surface Water Intakes - Michigan, Minnesota, and Wisconsin will promote the preparation and implementation of protection plans for water supply intakes on Lake Superior. A protocol has been developed for designating source water areas in the Great Lakes. These efforts have great potential to be coordinated with LaMP activities.

Canada/Ontario

In Canada, the Federal Department of Health (Health Canada) establishes, in collaboration with the provinces and territories, the *Guidelines for Canadian Drinking Water Quality* under the auspices of the Federal-Provincial Subcommittee on Drinking Water. The provinces and territories may then use these guidelines as a basis for establishing their own enforceable guidelines, objectives, or regulations. In Ontario, drinking water quality is addressed by the Ontario Drinking Water Objectives. There is no organized water quality monitoring program for private water supplies. However, the public water treatment plants are required to regularly monitor the finished water for chemical and microbiological quality as outlined in the Ontario Drinking Water Objectives. The Ontario Ministry of Environment’s Drinking Water Surveillance Program (DWSP) monitors raw (incoming source water), treated (at the treatment plant after water has been treated), and distributed water (at the consumer’s tap) at selected locations throughout the province for over 200 parameters. DWSP maintains a database of contaminant levels measured in raw, treated and distributed water from about one quarter of all municipal treatment plants in Ontario, representing about 85 percent of the population serviced by municipal water supplies (Health Canada 1998b).

5.1.1.4 Lake Superior Drinking Water Quality - Data

United States

Consumer Confidence Reports should eventually provide precise information on drinking water quality at community water systems. A review of the Consumer Confidence Reports for Lake Superior basin (reports reviewed are listed in the References section) indicate contaminants in the treated public drinking water supplies were all below federal standards for basin residents in Minnesota and Wisconsin in 1998, demonstrating good overall quality of treated drinking water. Water quality for private water systems is generally good based on available data and conversations with individuals working for agencies that assist those consumers or regulate private wells, but it is important to note that groundwater quality from private supply wells is variable within the basin due to well construction practices; naturally occurring contaminants such as arsenic, boron, chloride, mercury; and anthropogenic contaminants such as bacteria and nitrate (CDC 1994, MPCA 1999). A large portion of the residents that obtain their water from private wells also have on-site wastewater treatment systems. Data for Michigan public water systems and private drinking water supplies were not received in time for this draft.

A study evaluating septic systems conducted in 1991 and 1992 found a failure rate of fifty-five percent along the Minnesota shore of Lake Superior (WLSSD 1994). Tap water was also sampled and seven percent of the domestic wells failed to comply with Minnesota Department of Health Safe Drinking Water Standards due to coliform contamination. However, all of the drinking water samples were below the standard for nitrate.

During 1994, the U.S. Centers for Disease Control and Prevention and nine Midwest states, including Minnesota and Wisconsin, systematically sampled private wells throughout the upper

Midwest for total coliform bacteria, *E. coli*, nitrate, and atrazine (one well every 10 square miles). In Minnesota, 27.3 percent of private wells tested positive for total coliform bacteria, 4.5 percent showed fecal contamination (positive for *E. coli*), 5.8 percent exceeded 10 mg/l nitrate nitrogen, and 0.1 percent showed atrazine over 3 μg/l. In Wisconsin, 22.8 percent of private wells tested positive for total coliform bacteria, 2.6 percent showed fecal contamination (positive for *E. coli)*, 6.6 percent exceeded 10 mg/l nitrate nitrogen, and 0.2 percent showed atrazine over 3 μg/l.

In St. Louis County, Minnesota, approximately 2,000 private wells are tested each year for coliform bacteria and nitrate. It is estimated that 25- 40 percent of the wells tested will fail the Minnesota Department of Heath limits for bacteria or nitrate (Johnson 1999). Within the Lake Superior basin in Wisconsin, nitrate concentrations typically are low or near background levels because of a thick protective clay layer present in much of the basin. In those portions of the basin where permeable soils do exist, the low density of residential and farm populations have not caused excessive nitrate loading problems. Coliform can occur in some of the private wells in the area, but the coliform detects are more a reflection of water system type and installation deficiencies than the quality of the groundwater in the basin. The groundwater is typically free of coliform (Herrick 1999).

Canada/Ontario

Provincial and municipal agencies frequently monitor community water supplies, and information on the results of testing is usually available upon request. The Ontario Drinking Water Surveillance Program (DWSP) reports that of the 654,382 tests performed under DWSP in 1993- 1997, 99.98 percent met the health related drinking water objectives (OME 2000), demonstrating good overall quality of drinking water delivered by treatment plants. Contaminant monitoring from individual treatment plants provides more precise information on local drinking water quality. In addition, executive summaries of the performance of municipal water treatment facilities monitored under DWSP, for the years 1993-1995 and 1996 - 1997, can be accessed at DWSP's web site at http://www.ene.gov.on.ca/envision/dwsp/index96_97.htm (site specific reports are available through the Ministry of Environment's Public Information Centre at 1-800-565-4923 or 416 325-4000). In addition, some municipalities publish their own reports.

Health Canada's Great Lakes Health Effects Program has published graphic summaries of levels of seven selected chemicals (aluminum, atrazine+metabolites, lead, mercury, total nitrates, total trihalomethanes, and tritium) chosen as indicators of the chemical quality of municipally treated drinking water drawn from the Great Lakes, other surface waters, and groundwater (Health Canada 1998b). The summaries used DWSP data from 1988 to 1995. Drinking water treatment plants were grouped by individual Great Lake basin, including Lake Superior, and were further categorized into Lake Superior surface water, other surface water sources within Lake Superior basin, and groundwater within Lake Superior basin. These summary figures show that average contaminant levels for Lake Superior are very low. With the exception of aluminum, average levels of contaminants in the assessment are below drinking water guidelines, and most show relatively stable or declining trends. For aluminum, the Federal-Provincial Subcommittee on Drinking Water has established an operational guideline for aluminum, which is the same operational guideline of 100 µg/L for aluminum as set by Ontario, and treatment plants are working on optimizing their treatment processes to reduce levels of aluminum in their finished water (Health Canada 1998b).

5.1.1.5 Needs for Future Research

Since 1971, CDC and the U.S. EPA have maintained a collaborative surveillance system for collecting and periodical reporting of data that relate to occurrences and causes of waterborne disease outbreaks. Public education efforts should include educating the public on what the drinking water guideline values mean, eg. is it safe to drink the water if levels are above the guideline?

There is a need for a mechanism to collect data on the incidences of diseases from drinking water, and a need for the public dissemination of this information. At present, there is no active mechanism in the Great Lakes basin for the collection of data and evaluation of incidences of waterborne disease from drinking water. In Ontario, the regional public Health Units are currently the principal sources of information on infectious diseases (Health Canada 1998f). The Minnesota Department of Health collects information on waterborne disease outbreaks in Minnesota. The U.S. Centers for Disease Control also collects this type of data, but not every State provides reports. An active waterborne disease surveillance system, where this information is required to be submitted on an ongoing basis, would have many benefits, including a better understanding of the current status and factors associated with waterborne disease (CPHA 1995).

Data on raw water levels or even finished water for many contaminants is not always available (and some are only available in paper format). Data is just beginning to be put in electronic databases.

Raw water intake monitoring is the most cost effective, and is relevant to multiple users. This data can be can be used by state ambient surface water monitoring and assessment programs, state source water assessment and protection programs, state public water supply supervision programs, and water treatment plant operators.

Water chemistry data collected at drinking water intakes should be determined case-by-case, and include data on contaminants for which Maximum Contaminant Levels (MCLs) have been established under the National Primary Drinking Water Regulations (NPDWR), and for some of the contaminants for which treatment techniques have been established under the NPDWRs.

Microbiological and turbidity monitoring should be included in the monitoring program. Because these contaminants pose an acute health risk, treatment techniques are required no matter what the quality of the source water with respect to these contaminants, and that under no circumstances would a Total Maximum Daily Load (TMDL) developed under Section 303(d) of the Clean Water Act, and/or a source water protection program (SWPP) obviate the need for continuous treatment. However, the TMDL and/or a SWPP can help reduce the burden of treatment. Excessive turbidity can interfere with disinfection, contribute significantly to drinking water treatment costs, and overwhelm filtration with break through of protozoan pathogens to finished drinking water.

Total organic carbon (TOC), a precursor for the production of disinfectant byproducts, should be monitored where nutrient enrichment causes algae blooms in source water.

State Public Water Supply Supervision Programs currently have monitoring data on treated drinking water. Because small public water systems and private well owners are not required to regularly test for most chemical contaminants, data on such supplies have largely been limited to special studies, and are therefore incomplete. More information is also needed on the incidence of waterborne diseases from public versus private sources.

Very little data exist on taste and odour problems. Information is primarily anecdotal, although Ontario's Drinking Water Surveillance Program does collect data for geosmin and methyl isoborneol at selected locations, and many individual plants also have data.

People who live in an area that is served by a public water system probably don't need any other form of water treatment. Some people choose to install point-of-use devices (example activated carbon filters) to remove chemicals and improve the taste and odour of untreated water. It is important to be aware, however, that the manufacture and sale of water treatment devices for home use is currently unregulated in Canada and the U.S., although their devices are tested and registered by trade groups such as the Water Quality Association and the National Sanitation Foundation. Also, such equipment must be carefully maintained. Poorly maintained systems can become breeding grounds for bacteria and other contaminants.

5.1.1.6 Conclusions

Outbreaks of illness related to the use of drinking water are rare and the populations affected are small. The drinking water in the Lake Superior basin is of good quality. However, continuing efforts must be made to inform health professionals and the public of the results of analyses of drinking water.

Monitoring, and corrective measures to reduce and eliminate levels of contaminants in treated water are essential components in assuring the safety of drinking water supplies. Ultimately, source water protection is the key to maintaining the good quality of drinking water supplies.

Agencies (U.S. EPA, Health Canada, state, provincial and municipal agencies) are involved in a range of projects and initiatives to continually improve the protection of drinking water, and they are described in the LaMP 2000 Action Matrix as well as on the agency websites identified in Section 5.4 of this Chapter.

5.1.2 Environmental Contaminants in Lake Superior Basin Recreational Water

The Great Lakes are an important resource for recreation, including activities such as swimming and sailboarding which involve body contact with the water. Apart from the risks of accidental injuries, the major human health concern for recreational waters is microbial contamination by bacteria, viruses, and protozoa. (Health Canada 1998b, WHO 1998). Chemical pollutants may also pose health risks, but exposure to disease-causing microorganisms from sources such as untreated or poorly treated sewage is a greater risk (Health Canada 1999b).

5.1.2.1 Microbial Contaminants in Recreational Water

Many sources or conditions can contribute to microbiological contamination, including heavy rains that may cause combined or sanitary sewers to overflow (CSO or SSO) B Coliform densities have been observed to increase dramatically after periods of heavy rainfall (Whitman and others 1995). On-shore winds can stir up sediment or sweep bacteria in from contaminated areas. Animal/pet waste may be deposited on the beach or washed into storm sewers. Agricultural runoff such as manure is another source of contamination. Storm water runoff in rural and wilderness area watersheds can increase densities of fecal streptococci and fecal coliforms as well (Whitman and others 1995). Other contaminant sources include infected bathers/swimmers; direct discharges of sewage eg. from recreational and commercial vessels; and malfunctioning private systems -- eg. cottages, resorts (Health Canada 1998b, Whitman and others 1995, WHO 1998).

Human exposure to micro-organisms occurs primarily through ingestion of water, and can also occur via the entry of water through the ears, eyes, nose, broken skin, and through contact with the skin. Gastro-intestinal disorders, respiratory illness and minor skin, eye, ear, nose and throat infections have been associated with microbial contamination of recreational waters (Health Canada 1998b, WHO 1998, Prüss 1998). Consequently, one of the Specific Objectives of the Great Lakes Water Quality Agreement is that "recreational waters should be substantially free from bacteria, fungi, and viruses that may produce enteric disorders or eye, ear, nose, throat and skin infections or other human diseases and infections" (IJC 1987).

Studies have shown that swimmers and people engaging in other recreational water sports have a higher incidence of symptomatic illnesses such as gastroenteritis, otitis, skin infection, and conjunctivitis, and acute febrile respiratory illness (AFRI) following activities in recreational waters (Dewailly 1996, WHO 1998). Although current studies are not sufficiently validated to allow calculation of risk levels (Health Canada 1992), there is some evidence that swimmers/bathers tend to be at a significantly elevated risk of contracting certain illnesses (most frequently upper respiratory or gastro-intestinal illness) compared with people who do not enter the water (Dufour 1984, Seyfried 1985a and b, U.S. EPA 1986, WHO 1998, Prüss 1998). In addition, children, the elderly, and people with weakened immune systems are those most likely to develop illnesses or infections after swimming in polluted water (Health Canada 1998a).

Despite these studies, there are challenges in establishing a clear relationship between recreational water exposure and disease outcomes. Less severe symptoms resulting from exposure to micro-organisms are not usually reported , which makes statistics on cases related to recreational water exposure difficult to determine. In addition, the implicated body of water is not often tested for the responsible organism and when it is tested the organism is not usually recovered from the water. With the exception of gastro-intestinal illness, a direct relationship between bacteriological quality of the water and symptoms has not been shown -- a causal relationship exists between gastrointestinal symptoms and recreational water quality as measured by indicator-bacteria concentration (WHO 1998). Therefore, research efforts are focussing on conducting epidemiological studies to better establish the relationships between diseases and the presence of microorganisms in the water (Health Canada 1997, Health Canada 1998b, U.S. EPA 1999h).

5.1.2.2 Chemical Contaminants in Recreational Water

Chemical contaminants such as polycyclic aromatic hydrocarbons (PAHs) have been identified as a possible concern for dermal (skin) exposure in recreational waters. Dermal exposure to contaminants such as PAHs in sediment may occur when people swim in the water or come into contact with suspended sediment particulates in the water. PAHs adsorbed to these particulates would adhere to the skin. Research is ongoing to evaluate potential health effects of this route of exposure, including skin rashes and the potential to cause systemic effects, such as cancer (Hussain and others 1998, Lake Erie LaMP 1999).

A lifetime risk assessment from dermal exposure to PAHs in the St. Mary's River (Ontario, Canada) indicates that a lifetime health risk of skin cancer was well below the negligible risk range at inshore locations, but that some upstream sites had risk values higher than the negligible risk range and this may be cause for some concern. Strategies to reduce risk were developed with communities where the risk of exposure to PAH from recreational water use was increased. A key risk reduction recommendation was to take a bath or shower within 24 hours after a swim, thereby removing virtually all of the PAHs on the skin (Hussain and others 1998). Other sites in the Lake Superior basin where there are concerns about dermal contact with PAHs through swimming or wading include: two sites that are part of the St Louis River Area of Concern - Stryker Bay (part of the Interlake Superfund site in Duluth, Minnesota) and Hog Island inlet of Superior Bay in Superior Wisconsin; and a section of the Ashland, Wisconsin waterfront -- due to contamination from the Ashland coal tar site (Personal correspondence with Nancy Larson WI DNR 2000).

5.1.2.3 Protecting Public Health

Annex 2 of the Great Lakes Water Quality Agreement lists "beach closings" as an impairment of beneficial use related to recreational waters (IJC 1987). According to the International Joint Commission, a beach closing impairment occurs "when waters, which are commonly used for total body contact or partial body contact recreation, exceed standards, objectives or guidelines for such use" (IJC 1989).

For chemical contaminants in recreational water, some jurisdictions may issue human contact advisories to indicate that it is not safe to go into the water in these areas because of concern for exposure to specific chemicals (Lake Erie LaMP 1999).

For microbial contaminants, Federal, State and Provincial recreational water quality guidelines recommend bacterial levels below which the risk of human illness is considered to be minimal. In the U.S., states, territories, and Indian tribes set water quality standards for waters within their jurisdictions. The water quality standards program is administered by the U.S. EPA, which is mandated by Congress to provide water quality criteria recommendations, approve state-adopted standards for interstate waters, evaluate adherence to the standards, and oversee enforcement of standards compliance. Guidance for the development of standards by individual states, tribes, and territories is contained in the EPA documents Water Quality Standards Handbook, Second Edition (U.S. EPA 1983) and Ambient Water Quality Criteria for Bacteria (U.S. EPA 1986). Bacteriological water quality standards for each U.S. State are outlined on the U.S. EPA's web site at http://www.epa.gov/OST/beaches/local/sum2.html. The tables on this web site contain updated information on the bacterial water quality standards that have been adopted by states, territories, and tribes to protect human health from waterborne diseases within their jurisdictions. (U.S. EPA 1998j).

Canada

In Canada, regulations on recreational water quality are a provincial and territorial responsibility. Health Canada worked with officials in these areas to develop and publish national guidelines for recreational water quality. The *Guidelines for Canadian Recreational Water Quality* are available from Health Canada, and are also on Health Canada's website at http://www.hc-sc.gc.ca/ehp/ehd/catalogue/bch_pubs/recreational_water.htm. These guidelines help to ensure that recreational waters are as free as possible from microbiological, physical and chemical hazards. To determine the risk of disease, the guidelines recommend conducting an environmental health assessment or sanitary survey at the beginning of each bathing season. (Health Canada 1999b).

For public beaches, the regional Public Health Units/Health Departments monitor beach water quality. When contaminant indicator levels in the bathing beach water reach levels that are considered to pose a risk to health, public beaches may be posted with a sign warning bathers of these potential health risks. The primary tool used at present to evaluate beach water quality is the measurement of indicator organisms which estimate the level of fecal contamination of the water. The two indicator organisms most commonly used are fecal coliforms (coliforms are bacteria found in the intestinal tract of humans and animals; their presence in ambient water indicates fecal pollution and the potential presence of pathogens) and Escherichia coli (*E. coli*) (the fecal coliform organism exclusively found in human and animal feces). High levels of these organisms in recreational water are indicative of fecal contamination and the possible presence of intestinal disease-causing organisms. (Health Canada 1998b, Lake Erie LaMP 1999, WHO 1998).

In Ontario, the local Public Health Units monitor the water quality at public beaches on a regular basis throughout the bathing season, following the sampling and posting criteria detailed in the "Beach Management Protocol, Water Quality Program" (Ontario Ministry of Health 1992). In Ontario, *E. coli* is used as the indicator of recreational water quality (Ontario changed its guideline from fecal coliform to *E. coli* in 1992). Local health authorities are also responsible for investigating any illnesses resulting from bathing at public beaches. If the number of reported problems is unusually high the authorities will either increase their monitoring of water quality or temporarily close the beach to the public. In some cases, such as an outbreak of illness, tests for disease-causing organisms, like viruses, are conducted. (Health Canada 1999b, Lake Erie LaMP 1999).

United States

The U.S. EPA uses *E. coli* or enteroccocci as indicators of recreational water quality, and there is an increasing move by States toward their use, especially *E. coli*, since it is better correlated with gastrointestinal illness than fecal coliforms, and elevated fecal coliform counts do not always indicate a human health hazard (fecal coliforms include many species which are not exclusively found in human and animal wastes). (U.S. EPA 1999c, Bartram and Rees 2000).

In the U.S., a number of initiatives have recently been developed to specifically address recreational water quality. The U.S. EPA established the BEACH Program in 1997 "to significantly reduce the risk of waterborne illness at the nation's beaches and recreational waters through improvements in recreational water protection programs, risk communication, and scientific advances" (U.S. EPA 1999c).

As a result of the Beach Program being instituted, U.S. EPA developed the *Action Plan for Beaches and Recreational Waters* ("BEACH Action Plan", EPA/600/R-98/079), a multi-year strategy for reducing the risks of waterborne illness to recreational water users. (U.S. EPA 1999e). The BEACH Action Plan describes EPA's actions to improve and assist in state, tribal, and local implementation of recreational water monitoring and public notification programs. In addition, the U.S. Federal Clean Water Action Plan was announced in 1998, and describes a series of actions designed to strengthen core clean water programs carried out by a number of U.S. governmental agencies (U.S. EPA 1998).

5.1.2.4 Lake Superior Recreational Water Quality Data

A determination of human health risk from swimming at Lake Superior beaches which exceed water quality standards has not been made. However, information on the bacteriologic condition of beaches and frequency of beach postings is available from a number of sources. At present three of the Lake Superior AOCs list beach closings as a beneficial use impairment in their Remedial Action Plans (St. Louis River, St. Marys River and Thunder Bay; for more information on Lake Superior AOCs go to: http://www.cciw.ca/glimr/raps/intro.html).

Ontario Public Health Units, who are responsible for the monitoring of Ontario public beaches, collect, document and house detailed data on the beaches they monitor, including: a beach pollution survey or similar report, either historical, or done at the beginning of the bathing season, to include information on potential sources of contamination impacting on the bathing beach area; *E. coli* data ; beach postings data; and additional information on beach conditions on the day of monitoring (rain, winds, temperature, visibility, etc.) (Lake Erie LaMP 1999). The Ontario Ministry of Environment has a historic database that identifies total annual beach postings for public beaches in Ontario from 1988 onward (OMEE 1995).

For U.S. States, some information on the current condition of beaches and potential population affected is available through the U.S. EPA's BEACH Watch Program, as well as the Natural Resources Defense Council's Testing the Waters - 1999: A Guide to Water Quality at Vacation Beaches (NRDC 1999). Under the U.S. EPA BEACH Program, the first National Health Protection Survey of Beaches, conducted in 1997, focused on the collection of beach-specific information from coastal and Great Lakes States. Data from the second annual Survey, conducted in the spring of 1999, can now be accessed on the BEACH Program website at http://www.epa.gov/OST/beaches/ (U.S. EPA 1999e). States compile information regarding exceedances of bacteria standards as part of their efforts to develop "non-attainment" lists required by section 303(d) of the federal Clean Water Act. States are also required to report incidences of beach closings every two years as part of their water quality reports to the U.S. EPA required by section 305(b) of the Clean Water Act.

When reviewing the data, it is important to note that, despite the potential risks to the public from gastrointestinal illness and other infections, water quality monitoring programs vary widely at the state and local levels. Different states and jurisdictions monitor for different indicator organisms, and also have different criteria and standards for postings or advisories. In addition, frequency of monitoring bacterial contamination at public beaches is highly variable around the lake. Because of this variability, it is difficult, and potentially misleading, to compare water quality between jurisdictions or summarize data for all beaches. Even within a beach, variability in the data from year to year may result from the process of monitoring and variations in reporting, and may not be solely attributable to actual increases or decreases in levels of microbial contaminants. It is important to keep these limitations in mind when looking at the recreational water quality data (Health Canada 1998b, U.S. EPA 1998a, NRDC 1999).

The limitations in the ability to compare frequency of exceedances of microbiological guidelines has posed a challenge for the development of a lakewide indicator to evaluate trends in recreational water quality. Traditionally, frequency of beach postings has been used as an indicator of recreational water quality, but the use of beach postings data as an indicator of trends in water quality also has limitations. Microbial exceedances are still a better measure of actual health risk related to recreational water quality, and recent discussions are leaning toward developing an indicator that uses microbial monitoring data, supplemented by beach postings data. This combination will give a much more informative picture about microbial quality of recreational use waters (IJC IITF Swimmability Workshop, October 1999).

Health Canada has developed a preliminary indicator of recreational water quality in the Canadian Great Lakes basin, based on measurements of the number of *E. coli* at selected Ontario public beaches. This indicator is published in "*Health- Related Indicators for the Great Lakes Basin Population: Numbers 1-20*" (Health Canada 1998b) For the Lake Superior basin, this indicator includes data for Thunder Bay public beaches monitored by the Thunder Bay District Health Unit.

5.1.2.5 Needs for the Future

There is a need to better understand the relationships between diseases and the presence of microorganisms in the water, and this type of research is ongoing. At present, there is no active mechanism in the Great lakes basin for the investigation of incidences, if any, of waterborne disease due to recreational water use. The present system is one in which health units/ departments and other entities submit available information on a voluntary basis. The development of an active waterborne disease surveillance system would be useful toward informed decision making, increased responsiveness, and better understanding of factors associated with waterborne disease (CPHA 1995, Health Canada 1998f).

Viruses and protozoa, although a concern in recreational waters, are difficult to isolate and quantify at present, and feasible measurement techniques have yet to be developed for these pathogens. (Health Canada 1998b,U.S. EPA 1999d). Efforts are ongoing to develop new and better ways to assess both viral and bacterial contamination in recreational waters. These include the development of tests to more rapidly evaluate water quality before exposure occurs, which would in turn allow improved public health protection by prompt beach postings and by alerting the public of a potential health risk (Health Canada 1998b, Lake Erie LaMP 1999). Rapid analytical methods are needed to identify risk before exposure takes place. Current microbial testing methods for indication of possible pathogen presence require 24 to 48 hours of incubation before problems can be detected, leaving ample time for exposure to occur (U.S. EPA 1998a).

The effects of CSO and SSO discharges on recreational waters need to be quantified. EPA is proposed to conduct research to determine pathogen occurrence and indicator relationships associated with wet weather flows (U.S. EPA 1998a).

Playing/walking in the shallow interstitial (sand/water interface) water of beaches is a popular activity for all ages, particularly for children, who play with water toys as well as splash extensively in these shallow waters. The public health implication of bacteria, viruses, and protozoa in shallow beach water is unknown. It would be of great public health benefit to gather data on types, concentrations, survival patterns and other relevant information on pathogens in the interstitial waters of Great Lakes beaches, to better understand whether there is a potential for environmental/health effects in these waters. Some investigatory work is currently ongoing for this issue. (Whitman 1995, Springthorpe 1999, Palmateer 1999).

Water can also be inhaled as a fine aerosol during vigorous recreational water activity, and there is an interest in better understanding the health risks associated with inhaling contaminated aerosols generated by splashing in the water, water-skiing, and other recreational water activities. (Health Canada 1997; Springthorpe 1999).

5.1.2.6 Conclusions

Although there have been sporadic outbreaks of illness related to the use of recreational water, it must be emphasized that the populations affected are probably small compared to the total population of the Great Lakes basin, and even compared to the total number of recreational bathers (Health Canada 1998b).

Agencies (U.S. EPA, Health Canada, state, provincial and municipal agencies) are involved in a range of projects and initiatives to continually improve the protection of recreational waters, and they are described in the LaMP 2000 Action Summary (Figure 5-1) as well as on the agency websites identified in Section 5.6 of this chapter.

5.1.3 Air Pollution - Environmental Contaminants in the Air We Breathe

Improvement and protection of air quality in the Lake Superior basin and definition of the consequences of long range transport are one of the ecosystem objectives developed for the Lake Superior LaMP (See Table 5-1). The Lake Superior Human Health Committee plans on addressing these issues to a greater extent in future LaMP documents. The following is a brief list of resources that can be accessed for further information on air related issues.

For the United States the Clean Air Act implemented by the U.S. EPA and State Agencies are primarily responsible for ensuring the quality of ambient air by regulating point and mobile source emissions to the environment (for more information refer to http://www.epa.gov/oar/oarhome.html); the Occupational Safety and Health Administration implements the Occupational Safety and Health Act which protects health in the workplace -- including health related to air quality (for more information refer to http://www.osha.org).

In Canada, Health Canada conducts air pollution health effects research, risk assessments and exposure guidelines creation through programs such as the Air Pollution Health Effects Research Program in its Environmental Health Directorate (http://www.hc-sc.gc.ca/ehp/ehd/bch/air_quality.htm), in addition the Province of Ontario has programs targeted at the protection of human from exposure to air pollution. (Soils/Sediments text from personal correspondence with Carl Herbrandson of Minnesota Department of Health 2000)

5.1.4 Environmental Contaminants in Soils/Sediments and Related Human Health Issues (Hebrandson 2000)

Just as soils are the ultimate fate of persistent chemicals in the air, sediments are a sink for chemicals in aquatic systems. While plants grow in soils and form the base of the terrestrial food chain, benthic organisms, living in sediments, lacking cell walls, and containing high proportions of lipids and fats in cell membranes and other organelles, are the base of the aquatic food chain. Thus, sediments are not merely a sink for hazardous compounds, but also a source of lipophilic compounds to the aquatic food chain and, potentially, to humans and other fish eaters.

It has become clear that the accumulation into the food chain of PBT chemicals, such as PCBs, dioxins and dibenzofurans, and mercury (as methylmercury), is not solely dependent on their concentration in sediments. Characteristics of the sediment such as organic content, microbial environment, pH, redox conditions, and presence of sulfates and sulfides can all affect the potential for PBT chemicals to be bioaccumulated. Furthermore, sediment reactions are typically characterized and studied as static systems. In the environment, though, reactions which occur may be affected by groundwater flow. Groundwater flow may cause water of groundwater or surface water origin to regularly replace porewater. Therefore, equilibriums between reactants and products may not be achieved, and production and/or transport of some compounds might occur at much higher rates than previously proposed. This is the basis of suppositions which may explain the continuing elevated levels of PCBs in fish in the Hudson River and may also explain some of the variability in methyl mercury production and ultimate accumulation in fish. Without a better understanding of the chemical reactions and interactions in this transition zone between groundwater and surface water, quantitative risk assessment of the potential effects of PBT contaminated sediments will remain associated with large uncertainties.

As mentioned above, there are numerous hazardous chemicals which have greater health impacts on ecological communities than humans when found at elevated levels in sediments. These include some metals, lead for example, and some organic compounds, such as PAHs.

Lead is an element which is often found at elevated levels in soil and dust in the terrestrial environment, but it can also be found at high concentrations in sediment. In soil, 400 ppm lead is of concern due to the potential for children to accidentally ingest quantities which could increase blood lead concentrations to levels which have been shown to impact development. Sediments with similar concentrations, while being at least as toxic as soil lead (methylation in sediment may increase the bioavailability - GI tract uptake - of lead and thereby increase its potential toxicity to animals) is not as accessible as bare soil, and therefore, ingestion of quantities over significant periods of time are unlikely. On the other hand, benthic organisms are much more susceptible to lead than are plants, showing effects at around 31 ppm, and therefore sediment criteria are often set below this level.

PAHs are toxic organic compounds which are persistent in the environment. They have been shown to cause cancer in humans and other animals. When found in sediments they may adversely affect benthic organisms, but human exposures are usually limited. Non-cancerous effects on waders or swimmers may include irritation of the skin, but as mentioned above, this effect would be expected to occur at concentrations significantly greater than those found to impact invertebrate populations. PAHs may also be accumulated by some aquatic organisms, typically those that are unable to metabolize PAHs. Fish and other vertebrates, though, are able to metabolize PAHs and therefore do not generally accumulate them. As a result, ingestion of fish exposed to reasonably high levels of PAHs usually does not significantly increase PAH consumption for humans or wildlife. It is possible that PAHs may accumulate in other aquatic species which are eaten by people, such as clams, mussels, and snails, but these animals are not typically harvested from waterbodies in the Great Lakes basin.

5.1.4.1 Needs for Future Work

While there are large databases containing information on the toxicity of various contaminants to aquatic organisms, most of the information was gathered in laboratory studies which do not accurately reflect conditions found in the environment. As a result our understanding of what takes place in the environment, the hydro- and geochemistry of contaminants and the toxicity, biotrophic, and ecological effects of mixtures, may be somewhat limited. Therefore, any analysis of the effects of sediment contamination on humans is usually restricted to qualitative evaluation and analysis of uncertainties.

5.1.5 Persistent Bioaccumulative Toxic Chemicals in Food/Fish

5.1.5.1 General Population Exposures to PBT Chemicals

People in the Great Lakes basin get their food from a global market, this general market basket diet contributes to over 95 percent of their intake of PBT chemicals. Exposure assessments from all sources (air, water, food and soil) were completed for the Canadian Great Lakes basin general population, for eleven PBT chemicals, including the nine chemicals designated for zero discharge for Lake Superior. The total estimated daily intake averaged over a lifetime was well below the Tolerable Daily Intake (TDI) established by Health Canada (Health Canada 1998c). Consequently, the approach by various agencies has been to examine groups at higher risk of exposure to persistent toxic substances from Great Lakes sources, such as high consumers of sport fish. At present six of the Lake Superior AOCs list restrictions on fish and wildlife consumption as a beneficial use impairment in their Remedial Action Plans (St. Louis River, Torch Lake, Deer Lake, St. Mary's River, Peninsula Bay and Thunder Bay; for more information on Lake Superior AOCs go to: http://www.cciw.ca/glimr/raps/intro.html)

5.1.5.2 PBT Chemicals in Human Breast Milk

In Canadian populations, Craan and Haines (1998) reported a downward trend from 1967 to 1992 in the concentrations of organochlorine pesticides and PCBs in human breast milk. A similar decline could be expected of organochlorine concentrations in human breast milk in the Great Lakes basin. (Craan and Haines 1998).

Nonetheless, trace levels of PCBs and other PBT chemicals are found in breast milk of the general population. Very little is known about the effects of exposure of infants to moderately high levels of organochlorines during the breast-feeding period. Jacobson and others (1992) did not find an association between breast-feeding and developmental deficits in his Michigan fish consumers study (Van Oostdam and others 1999). Rogan and others (1991) in reporting on the North Carolina Breast Milk and Formula Project, saw no evidence of adverse effects from exposure to PCBs or DDE through breastmilk, although they did report a subtle motor delay attributable to transplacental (in utero) exposure. Research is continuing into health risks of PBT chemical exposure from breast feeding and other exposure routes.

"There are many recognized advantages to breast-feeding to infants and to mothers, including improved nutrition, increased resistance to infection, protection against allergies, and better parent-child relationships. With full regard for the uncertainty over the toxic effects of organochlorines in human milk, the known benefits of breast-feeding are extensive and serve as a strong rationale for advising mothers to continue to breast-feed their newborns unless cautioned by their local health care worker to reduce or stop" (cited from Van Oostdam and others 1999).

5.1.5.3 PBT Chemicals in Fish

Fish are low in fat, high in protein, and may have substantial health benefits when eaten in place of high-fat foods. However chemicals such as mercury, polychlorinated biphenyls (PCBs), and toxaphene enter the aquatic environment and build up in the food chain of fish. The levels of the chemicals in fish from the Lake Superior basin are generally low and do not cause acute illness. Continued low level exposure to these chemicals however, may result in adverse human health effects. Therefore people need to be aware of the presence of contaminants in sport fish, and in some cases take action to reduce exposure to chemicals while still enjoying the benefits of catching and eating fish.

Many chemicals are present in surface waters at very low concentrations. Some of these chemicals can bioaccumulate in aquatic organisms via their diet and become concentrated at levels that are much higher than in the water itself. This is especially true for substances that do not break down readily in the environment i.e., persistent chemicals - like toxaphene and PCBs. In the process of feeding, these persistent chemicals are collected. Small fish and zooplankton eat large quantities of phytoplankton. In doing so, any toxic chemicals accumulated by the phytoplankton are further concentrated in the bodies of the animals that eat them. This is repeated at each step in the food chain. The concentration of some chemicals in the tissues of top predators, such as lake trout and large salmon, can be millions of times higher than the concentration in the water. Although bioaccumulative chemicals are present in other food, the concentrations that build up in fish, due to the number of steps in the food chain of fish, are much higher than in other food. Figure 5-2 shows an example of the changes in PCB concentration (in parts per million, ppm) at each level of a Great Lakes aquatic food chain. The highest levels are reached in the eggs of fish-eating birds such as herring gulls (Government of Canada and U.S. EPA 1995).

Figure 5-2 shows the degree of concentration in each level of the Great Lakes aquatic food chain for PCBs (in parts per million (ppm). The highest levels are reached in the eggs of fish-eating birds such as herring gulls.

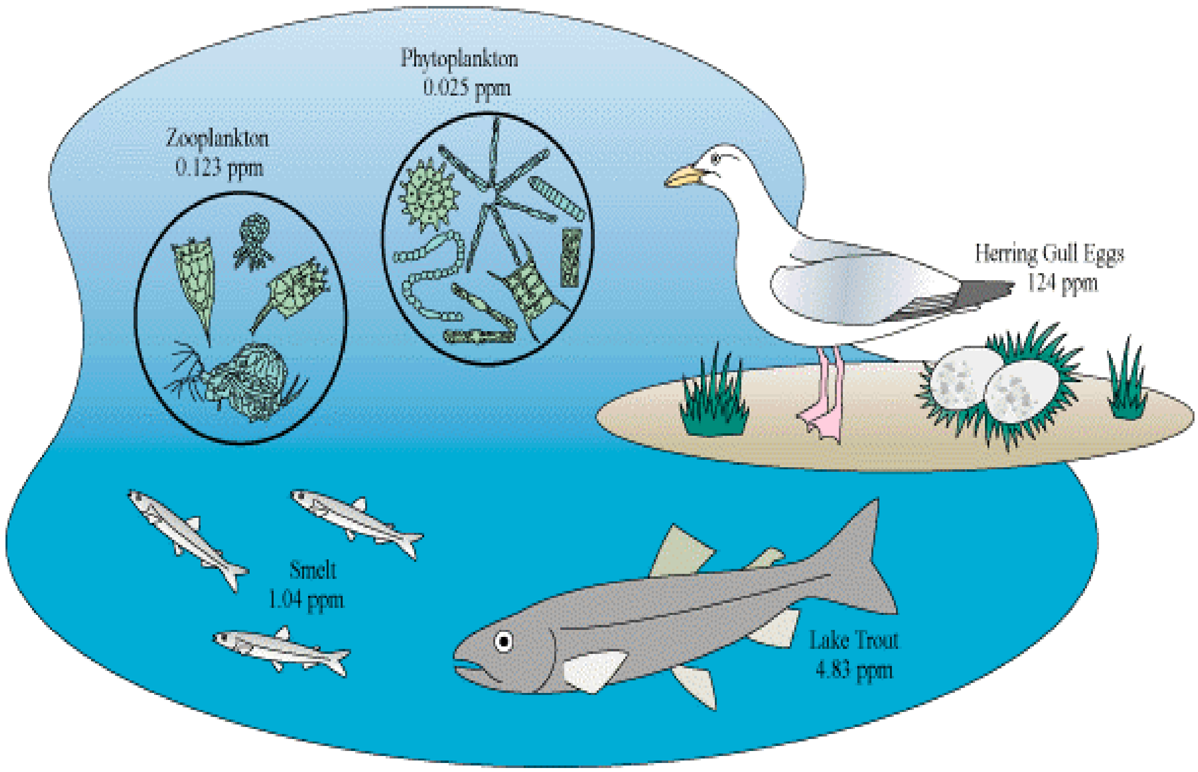

Figure 5-2. Persistent Organic Chemicals, such as PCBs, Bioaccumulate

Figure Taken from: "The Great Lakes: An Environmental Atlas and Resource Book," (Government of Canada and U.S. EPA 1995).

All food, including fish, contain environmental contaminants. Federal government agencies restrict the sale of fish based on environmental contaminants in the edible portion. When setting the acceptable level of a contaminant in commercial fish, federal governments take into account several factors in addition to potential health effects including: assumptions about how much fish people eat, the species consumed, where the fish come from, and economic considerations.

State and provincial governments provide information to consumers regarding consumption of sport-caught fish. This information is not regulatory - its guidance, or advice. Although some states use the Federal commercial-fish guidelines for the acceptable level of contaminants when giving advice for eating sport caught fish, consumption advice offered by most agencies is based on human health risk. This approach involves interpretation of studies of health effects from exposure to contaminants. Evidence for Potential Health Effects: Linking Environmental Exposure, Section 5.2, of this report summarizes the major studies of effects from exposure to PBT chemicals. Each state or province is responsible for developing fish advisories for protecting the public from pollutants in fish and tailoring this advice to meet the health needs of its citizens. As a result, the advice from state and provincial programs is sometimes different for the same lake and species within that lake.

The toxic endpoints used in risk assessments for calculating safe fish consumption levels are subtle (the effects are not easily recognizable or attributable to a particular exposure and that exposure does not cause immediate harm). Numbness of fingertips, dizziness, and the sensory loss that might occur from toxic exposures to methylmercury, might easily be attributed to getting old. Developmental problems resulting from in-utero exposure to PCBs are difficult to measure or even separate from confounding factors like smoking or alcohol consumption. The variability in response of individuals exposed to PBT chemicals dictates a more conservative approach, perhaps producing guidance that is over protective of a large portion of the population.

It is important that people are aware of contaminants in fish and the actions that can be taken to reduce exposure, particularly those people who are at greatest risk from those exposures from overexposure to contaminants found in fish. Exposure to detrimental levels of environmental contaminants can cause a variety of negative health effects. The precise level of contaminant exposure that is detrimental to an individual is going to vary with his/her age, sex, genetics, current physical condition, and previous exposure of that individual. Individuals within a population will vary in their sensitivities to environmental contaminants. It is not possible to determine *a priori* which individuals within a population are going to be most sensitive to contaminant exposure. Because governments need to protect sensitive individuals in the population, the advice governments provide may be over protective for some portion of the population.

While the average person in the Lake Superior basin may not be at risk of experiencing adverse health effects from exposure to contaminants through the consumption of fish, there are some people who are at risk. These include people who eat a lot of fish, regularly eat large predator fish, eat fish from highly contaminated waters, or eat a large amount of fish over a short period of time. In addition, the developing fetus and young children are at greater risk than adults.

Nursing women are generally given the same consumption advice as pregnant women and other women of child-bearing age. This advice is given because of the potential for another pregnancy. The benefits of breast feeding are well established, and research studies looking at effects in infants of mothers who consume large amounts of contaminated fish attribute health effects to *in utero* exposure to PBT chemicals rather than to maternal breast milk (Johnson and others 1998). In general, exposure to contaminants in fish can be reduced by:

- eating panfish rather than predator fish (panfish have lower concentrations of contaminants because they are lower on the food chain)
- eating smaller predator fish (smaller fish are generally younger and have had less time to build up contaminants)
- spacing meals out over time (some contaminants like mercury are eliminated by the human body)
- removing as much fat as possible when cleaning and cooking fish (organochlorine contaminants are stored in the fat, mercury is stored in the protein and so is not reduced by cooking and cleaning)

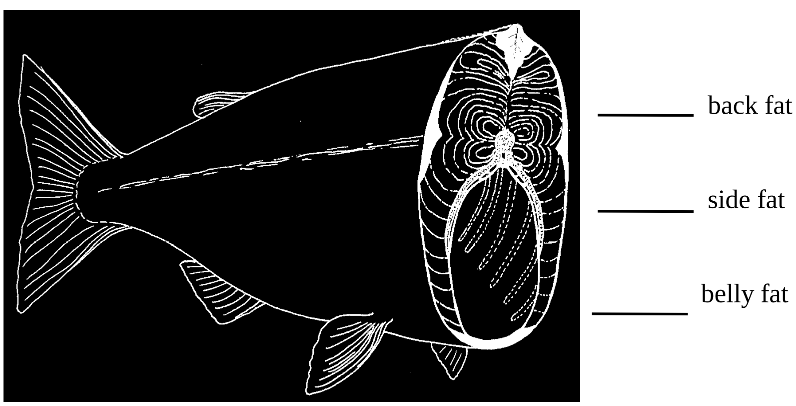

Figure 5-3 Wisconsin Sea Grant Fish Cleaning Diagram

5.1.5.4 Protecting Public Health

Fish Consumption Programs are well established in the Lake Superior basin. The states of Michigan, Minnesota and Wisconsin, the Province of Ontario, and many tribes in the basin have extensive fish contaminant monitoring programs and issue advice to their residents about how much fish and which fish are safe to eat. This advice ranges from recommendations to not eat any of a particular size of certain species from some waterbodies, to recommending that people can eat unlimited quantities of other species and sizes. Advice from these agencies to limit consumption of fish from Lake Superior is mainly due to levels of PCBs, mercury, chlordane, dioxin, and toxaphene in the fish.

Fish consumption advice for Lake Superior is communicated to the public in a variety of ways. The Province of Ontario, some tribes, and the three U.S. states that border Lake Superior publish annual or biannual information on waterbodies from which fish have been tested for contaminants and give specific consumption advice for these fish. Advisory information is also available in formats designed for particular populations such as factsheets translated into immigrant languages, low-literacy fact sheets, and brochures created to inform women of childbearing age of risks to the fetus. These booklets and brochures are available at no charge to the public and many are available on the Internet.

Advice to limit consumption of fish from inland lakes in the basin is generally based on the presence of mercury in these fish. Since mercury can be transported long distances in the atmosphere and then deposited in lakes, even fish in remote lakes far away from human activity can have mercury levels high enough to warrant consumption advice. Due to the presence of mercury in fish from virtually all inland lakes, the three states in the basin and the Province of Ontario, each issue advice to women of childbearing age to limit consumption of fish from inland lakes. The table below summarizes this advice. Due to mercury levels, Minnesota and Ontario also give advice to women of childbearing age regarding consumption of shark, swordfish, and tuna.

Table 5-2 Mercury-Based Consumption Advice for Childbearing Age Women and Children for Fish from Inland Lakes

State or Province	Type of Fish	Meal Frequency Advice
Michigan	any size predator fish and panfish over 9 inches in length	one meal per month
Minnesota[a]	panfish	one meal per week
	other fish less than 20 inches	one meal per month
	other fish greater than or equal to 20 inches	do not eat
Wisconsin	fish with 0.5 ppm or less mercury	one meal per month[b]
	fish with greater than 0.5 ppm mercury	do not eat[c]
Ontario	fish with 0.45 ppm or less mercury	four meals per month
	fish with greater than 0.45 ppm mercury	do not eat

a Advice shown in table is for women who eat fish all year round
b Applies to pregnant women only
c Applies to women of childbearing age and children under fifteen

There are many potential barriers to communication of fish consumption advice. People who fish a lot feel confident and familiar with the risks and may not be interested in hearing about the advisory or are skeptical of the concern because they have not seen any apparent effects. There may be barriers of literacy and access, such as with new immigrants. Economic barriers may exist for subsistence fishers. Cultural barriers also exist regarding choice of fish species, releasing fish, and cooking and cleaning practices.

Studies have shown that having an awareness of health advisories can be successful in changing fishing and fish consumption habits (Fiore and others 1989; Velicer and Knuth 1994). The communication programs in the Great Lakes generally target white, licensed anglers and may not be reaching other sensitive populations B minorities, immigrants and women of child bearing age (Tilden and others 1997, Velicer and Knuth 1994). Written information (i.e., regulation booklets and advisory brochures) is circulated by the government and the fishing industry to licensed anglers, and these sources of information appear to be effective in reducing consumption of contaminated fish. For example, Fitzgerald and coworkers (1999) found that 97 percent of the men in their study were aware of fish advisories and two-thirds of these men had reduced their fish consumption. This reduction in fish consumption was due to public health intervention strategies such as risk communication along with the use of fish advisories. More recent efforts have been directed toward groups with less awareness of health advisories such as women of childbearing age, minorities, and other frequent fish consumers (Knuth 1995, Tilden and others 1997).

5.1.5.5 Needs for the Future

Fish advisories are issued because health officials assume that some people eat more fish than recommended in the advisory guidelines. U.S. EPA estimated that 7 percent of women of childbearing age and 25 percent of children in the U.S. are exposed to more mercury in their diet from fish consumption than is considered safe (U.S. EPA 1997a). Fish consumption advice is communicated through distribution of printed materials, press releases, public presentations, local public health agencies, and health care providers. There has been minimal evaluation of the effectiveness of these communications both in the advice reaching the at risk populations and in the successful communication of the message. Studies of fish advisory awareness in the Great Lakes basin generally report an awareness of approximately 40 to 50 percent among residents.

<u>Wildlife</u>: PBT chemicals are also a concern for consumption of wildlife, particularly fish-eating waterfowl. In addition there are concerns with respect to lead exposure when consuming game birds harvested with lead shot shells. Some research is currently available looking at PBT chemicals and lead shot exposure in wildlife. Although not discussed in this chapter, subsequent LaMP reports will address this issue.

<u>Surveillance:</u> There is a need for surveillance to evaluate how much fish people eat and carry out biomonitoring to determine actual tissue levels, particularly within sensitive populations (Great Lakes Sport Fish Advisory Task Force 1999). Surveys have been carried out in the Lake Michigan and Lake Ontario basins. However Lake Superior basin residents may have different fish eating habits than residents from these basins. For example, differences exist in the fishery itself and in the charter industry. Some bio-monitoring data will be available within the next year

for MN and WI residents from the U.S. EPA project summarized above. However, at this time it is not known how many of the participants live in the Lake Superior basin. Mercury analysis of participants hair in the EERC ND/MN Fish Consumption Survey Project could be added with additional source of funding. A limited number of hair analysis is currently planned for in this project.

<u>"Can we eat the fish?" Indicator:</u> The various long-term fish contaminant monitoring data sets that have been assembled by several jurisdictions for different purposes need to be more effectively utilized. Relationships need to be developed that allow for comparison of existing data from the various sampling programs (Whittle 1999).

<u>Awareness:</u> Fish advisory awareness among Lake Superior basin residents needs to be increased. Tilden and coworkers (1997) conducted a population-based survey of fish consumption within the eight Great Lakes states. The study results demonstrated that almost 50 percent of the Great Lakes fish consumers had an awareness of the health advisories. Of the 50 percent, approximately 60 percent of the males were aware of the advisories with less than 40 percent of the females having an awareness. These findings emphasize the importance of targeting health advisories to sensitive groups such as women of reproductive age. The sensitive groups include women of childbearing age and their fetuses and infants, the elderly, sports anglers, and minorities. (MN DNR survey 1998).

<u>Evaluation:</u> The evaluation of health advisories is an integral part of determining the effectiveness of a program. The U.S. EPA's Guidance document for fish advisories (EPA 1995) makes recommendations for evaluating the risk communication efforts for fish advisories and provides a step-by-step approach for conducting an evaluation of an existing program. Program evaluation is necessary to determine 1) if the health advisory is reaching the target population, 2) if it is being implemented properly, 3) if it is effective, 4) the cost, and 5) the cost relative to effectiveness (Windsor and others 1994).

<u>Benefits:</u> The benefits of eating fish need to be quantitatively incorporated into the risk assessment for fish consumption advice. Benefits are qualitatively taken into account by providing statements about the benefits in the published information (TERA 1999). U.S. EPA funded a project to develop a framework to incorporate benefits of fish consumption into state fish advisories (TERA 1999). At this point the framework is qualitative and is undergoing external peer review. Quantitative assessment of benefits of fish consumption relative to the risks from contaminants has been ranked as a high priority among U.S. states issuing fish advisories. The U.S. EPA project will identify research needs that are not currently funded.

5.1.5.6 Conclusions

Diet contributes over 95 percent of the PBT chemical intake for the general population, with drinking water, recreational water, and air constituting very minor exposure routes. Consequently, the approach by various public health agencies has been to focus on groups at higher risk of exposure to PBT chemicals from Great Lakes Sources, such as high consumers of sport fish. Because of the presence of PCBs, organochlorine insecticides, mercury, and other chemicals found in fish from the Lake Superior basin, fish advisories are issued that recommend restrictions on fish consumption, with tighter restrictions (in some cases to the point of complete elimination) of fish from the diet of pregnant women, women of childbearing age and children. In communicating health risk information to fish consumers, it is important to remember that fish are also a good source of low-fat protein, and that the activity of sport fishing has social and cultural benefits.

5.2 EVIDENCE FOR POTENTIAL HEALTH EFFECTS - THE WEIGHT OF EVIDENCE APPROACH TO LINKING ENVIRONMENTAL EXPOSURE

The following three subsections describe selected studies which have reported associations between PBT chemical exposures and effects in wildlife, laboratory animals and human populations. Because of the ethical issue of exposing humans to toxic substances and factors such as small sample sizes and the presence of multiple chemicals, human studies are often limited in their ability to establish a causal relationship between exposure to chemicals and potential adverse human health effect. In addition, human studies looking at causal relationships between human exposure to environmental contaminants and adverse health outcomes are limited and the results uncertain. In addition, there are not that many human studies, and there are uncertainties around these studies. Therefore, a weight of evidence approach is used, where the overall evidence from wildlife studies, experimental animal studies, and human studies is considered in combination. Therefore, a weight of evidence approach is used, that is the overall evidence from wildlife studies, experimental animal studies, and human studies is considered. It utilizes the available information from wildlife and controlled animal experiments to supplement the results of human studies toward assessing the risks to human health from exposure to PBT chemicals. The use of wildlife data assumes that animals can act as sentinels for adverse effects observed in humans (Johnson and Jones 1992).

5.2.1 Wildlife Populations

Research over the past 25 years has shown that a variety of PBT chemicals in the Great Lakes food chain are toxic to wildlife (Health Canada 1997). Reproductive impairments have been described in avian, fish, and mammalian populations in the Great Lakes. For example, egg loss due to egg shell thinning has been observed in predatory birds, such as the bald eagle, within the Great Lakes (Menzer and Nelson 1980). After feeding on Great Lakes fish for two or more years, immigrant birds (eagles) were shown to have a decline in reproductive success (Colburn and others 1993). Developmental effects in the form of congenital deformities (e.g., crossed mandibles, club feet) have also been reported in the avian population within the Great Lakes basin (Stone 1992).

Effects to the endocrine system and tumor formations have been detected in fish populations. Researchers have reported enlarged thyroids in all of the 2 to 4 year-old Great Lakes salmon stocks that were examined (Leatherland 1992). Tumors associated with exposure to high levels of polyaromatic hydrocarbon compounds have also been detected in brown bullhead fish in the Great Lakes area (Baumann and others 1982).

Table 5-3 Effects of PBT Chemicals on Fish and Wildlife in the Great Lakes

Species	Population decrease	Effects on Reproduction	Eggshell thinning	Birth defects	Behavioral changes	Biochemical changes	Mortality
Mink	✓	✓	NA	NE	NE	NE	✓
Otter			NA	NE	NE	NE	S
Double-crested cormorant	✓	✓	✓	✓		✓	S
Black-crowned night heron	✓	✓	✓	✓		✓	S
Bald eagle	✓	✓	✓	NE		NE	NE
Herring gull		✓	✓	✓	✓	✓	✓
Ring-billed gull				✓		NE	✓
Caspian tern		T		✓	NE	NE	
Common tern		✓	✓	✓		✓	
Forster's tern		✓		✓	✓	✓	
Snapping turtle	NE	✓	NA	✓	NE	NE	NE
Lake trout		✓	NA			✓	
Brown bullhead			NA			✓	
White sucker			NA	✓		✓	

Source: U.S. EPA's National Water Quality Inventory: 1992 Report to Congress.

Notes:

NA = not applicable
NE = not examined
S = suspected

Effects on the immune system have also been a notable finding. At a number of Great Lakes sites, a survey of herring gulls and Caspian terns demonstrated a suppression of T-cell-mediated immunity following prenatal exposure to organochlorine pollutants particularly PCBs (Grasman and others 1996). Table 5-3 summarizes the observations for the main categories of these adverse effects. These effects have not been seen in all species, in all locations, or in all years, but provide proof that such effects can occur when exposure is sufficient (Health Canada 1997).

5.2.2 Animal Experiments

A number of animal experiments have demonstrated a wide range of health outcomes from exposure to PCBs, mercury and chlorinated dibenzo-p-dioxins (CDD).

PCBs (polychlorinated biphenyls): Animals exposed orally to PCBs developed effects to the hepatic,immunological, neurological, developmental and reproductive systems. Effects have also been reported in the gastrointestinal and hematological systems (ATSDR 1998). Animal ingestion studies strongly support the finding that higher chlorinated PCB mixtures (i.e., 60 percent chlorine by weight) are carcinogenic to the livers of rats, while the lower chlorinated PCBs are weaker animal carcinogens (i.e., lower incidence of total tumors and more benign tumors) (Buchmann and others 1991, Sargent and others 1992). A General Electric Company sponsored study demonstrated the carcinogenicity of Aroclor-1016, Aroclor-1242, Aroclor-1254, and Aroclor-1260 in rats receiving dietary exposure to PCBs. As an example, liver tumors were observed in female rats, and thyroid cancers were reported in male rats (Brunner and others 1996).

A number of animal studies have demonstrated immune effects following exposure to PCBs (Arnold and others 1995, Tryphonas 1995, Ross and others 1996). In a laboratory study, harbor seals were administered a diet of Baltic sea herring contaminated with organochlorine compounds and other pollutants (Ross and others 1996). When compared with seals given a diet of relatively uncontaminated Atlantic Ocean fish, the seals ingesting the contaminated sea herring were found to have impaired natural killer cell activity and T-lymphocyte function.

Neurobehavioral effects have been seen in monkeys, exposed orally from birth to 20 weeks, to a PCB congener mixture representative of the PCB mixture found in the breast milk of Canadian women (Rice 1997). The monkeys were subsequently tested at 2.5 and 5 years of age, and found to have deficits in learning and difficulty in learning complex tasks when compared to controls.

Mercury: Long-term, high level animal ingestion exposure to mercury has been associated with cardiovascular (Arito and Takahashi 1991), developmental (Fuyuta and others 1978, 1979; Nolen and others 1972; Inouye and others 1985), gastrointestinal (Mitsumori and others 1990), immune (Ilback 1991), renal (Yasutake and others 1991, Magos and others 1985, Magos and Butler 1972, Fowler 1972), and reproductive effects (Burbacher and others 1988, Mitsumori and others 1990, Mohamed and others 1987). The studies also indicate that the nervous system is particularly sensitive to mercury exposure by ingestion (Fuyuta and others 1978; Inouye and Murakami 1975; Magos and others 1980 and 1985).

In addition, growth of kidney tumors has been reported in animals administered methylmercury in drinking water or diet for extended periods (Mitsumori and others 1981 and 1990). The U.S. EPA Mercury Study Report to Congress, Volume V: Health Effects of Mercury and Mercury Compounds, 1997, provides a good summary of methylmercury toxicity.

CDDs (chlorinated dibenzo-p-dioxins): In specific species (e.g., guinea pig), very low levels of 2,3,7,8-TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin) have resulted in the death of the exposed animal after a single ingestion dose (NTP 1982). At nonlethal levels of 2,3,7,8-TCDD by ingestion, other effects reported in animals include weight loss (NTP 1982), biochemical and degenerative changes in the liver (NTP 1982, Kociba and others 1978), and a decline in blood cells (Kociba and others 1978). Dermal effects in animals (e.g., hair loss, chloracne) have also been reported by ingestion exposure (Mc Connell and others 1978). In many species, the immune system and fetal development are particularly susceptible to 2,3,7,8-TCDD exposure. Offspring of animals receiving oral exposure to 2,3,7,8-TCDD developed birth defects such as skeletal deformities and kidney defects, weakened immune responses, impaired reproductive system development, and learning and behavior impairments (Giavini and others 1983, Gray and Ostby 1995, Tryphonas 1995, Schantz and Bowman 1989, Schantz and others 1992). Reproductive effects in the form of miscarriages were reported in rats, rabbits, and monkeys exposed orally to 2,3,7,8-TCDD during pregnancy (McNulty 1984). Rats of both sexes were observed to have endocrine changes in the form of alterations in sex hormone levels with dietary exposure. Other reproductive effects include a decline in sperm production in male rats, and carcinogenic effects of cancer of the liver, thyroid, and other sites in rats and mice exposed orally to 2,3,7,8-TCDD (NTP 1982, Kociba and others 1978). Research evidence is also increasing, supporting the neurotoxic effect for mammals and birds from ingestion exposure to dioxin-like compounds, including certain PCBs and CDFs. Changes in thyroid hormones and neurotransmitters, singly or together, at critical periods in the development of the fetus are considered responsible for the neurological changes (Brouwer and others 1995, De Vito and others 1995, Henshel and others 1995b, Henshel and Martin 1995a, Vo and others 1993).

5.2.3 Human Health Studies

Demonstrating health effects in humans from chronic, low-level exposure to persistent organic pollutants typically encountered in the Great Lakes region is a challenge for researchers. Human epidemiological studies are limited in their ability to separate health effects attributable to contaminant exposures from those related to other known health factors like smoking, alcohol intake and general health status. In addition, exposure to contaminants from Great Lakes fish is dependent upon the amount eaten and species consumed. For the Lake Superior basin, there is little information available on exposure levels, body burdens and health effects for people who consume fish in and around Lake Superior. Consequently, results from studies in other areas of the Great Lakes basin are used to assess risks and benefits of eating Great Lakes fish.

5.2.3.1 Exposure Studies

Fish species residing in waters contaminated with lipophilic pollutants (i.e., fat-soluble pollutants as PCBs) bioaccumulate these contaminants and become a further source of contamination for larger, predator fish (e.g., sport caught trout and salmon) (Humphrey 1988). This process results in a biomagnification or increase in the levels of contaminants in the predator fish which may subsequently be consumed by humans. Fish consumption has been shown to be a major pathway of human exposure to persistent toxic substances such as PCBs (Birmingham and others 1989; Fitzgerald and others 1996; Humphrey 1983; Newhook 1988), exceeding exposures from land, air, or water sources (Humphrey 1988).

Early investigations of Lake Michigan fish consumption have broadened our knowledge about transmission of contaminants from fish to humans, including maternal exposure of the fetus and infant. Investigating a cohort of Lake Michigan fisheaters, Humphrey (1988) discovered that sport anglers who regularly consumed Great Lakes salmon and trout (consumption rate of $\geq$ 24 pounds/year [or 11 kg/year]) had median serum PCB levels approximately 4 times higher (56 ppb) than those who consumed no Lake Michigan fish (15 ppb) (consumption rate of 0-6 pounds/year [or 0-2.7 kg/year]). Halogenated contaminants (e.g., PCBs) have also been detected in adipose tissue, breast milk, and cord blood, associated with consumption of contaminated fish (ATSDR 1998). Other studies have also supported these findings. For example, Schwartz and others (1983) demonstrated that consumption of Lake Michigan fish was positively associated with the PCB concentration in maternal serum and breast milk. Maternal serum PCB concentrations were also positively associated with the PCB levels in the umbilical cord serum of the infant (Jacobson and others 1983). Several studies of exposure to methylmercury through fish consumption are ongoing outside the Great Lakes basin. There have been no large-scale epidemiological studies of fish-eating population in the Lake Superior basin.

Although the levels of PCBs have declined in most species of Great Lakes fish, lipophilic pollutants, such as PCBs, have a tendency to bioaccumulate in the human body. Hovinga and others (1992) reported a mean serum PCB concentration of 20.5 ppb in 1982 for persons consuming >24 pounds of Lake Michigan sport fish per year, and 19 ppb in 1989 demonstrating little decline within the 7 year interval. For those ingesting <6 pounds of Lake Michigan sport fish per year, the mean serum PCB concentrations were 6.6 ppb in 1982, and 6.8 ppb in 1989. The mean serum PCB concentrations for those consuming <6 pounds of Lake Michigan fish per year are comparable to the mean serum PCB levels of 4 to 8 ppb found in the general population who do not have occupational PCB exposure (Kreiss 1985).

Research has shown that at-risk communities for exposure to contaminants from fish consumption include Native Americans, minorities, sport anglers, elderly, pregnant women, and fetuses and infants of mothers consuming contaminated Great Lakes fish (Dellinger and others 1996, Fitzgerald and others 1996, Lonky and others 1996, Schantz and others 1996). These communities may consume more fish than the general population or may have physiologic attributes such as physical and genetic susceptibilities that may cause them to be at greater risk. Higher body burdens of mean serum PCBs and DDE were found in an elderly cohort of Lake Michigan fisheaters (i.e., >50 years of age) who were compared to nonfisheaters (Schantz and others 1996). Fisheaters had mean serum PCB levels of 16 ppb while the nonfisheaters had mean levels of 6 ppb. For DDE, fisheaters had mean serum levels of 16 ppb and the nonfisheaters had a mean level of 7 ppb.

Gender difference in fish consumption is an issue of interest that is being investigated, toward better identifying at-risk populations. One Lake Michigan sport anglers study, with subjects between the ages of 18-34 years, also demonstrated gender differences with males tending to consume more fish than female subjects (Courval and others 1996). Conversely, Health Canada's Great Lakes Fish Eaters Study (discussed below) found that women in the high fish consumption group eat more fish than men (Kearney 2000, personal communication).

In a recent Health Canada study carried out in five Areas of Concern in the lower Canadian Great Lakes (Dawson 2000), 4,637 shoreline fishers were interviewed. The demographic data show that there is no such thing as a "typical" fisher. People who like to fish come from different cultural backgrounds, are different ages and have different occupations. Thirty-eight percent or 1,762 of those interviewed, reported eating at least one meal of fish during the previous 12 months. Twenty-seven percent (465 individuals) of shoreline fishers interviewed reported eating more than 26 meals of fish in a year. As the number of fish meals consumed increased, so did the likelihood that parts of the fish other than the fillet were being consumed. Approximately one-third of the fish eaters said that they used the *Guide to Eating Ontario Sport Fish*.

A concurrent project, the Great Lakes Fish Eaters Study (not yet released) took a more in-depth look at exposure to environmental contaminants in people eating large amounts of Great Lakes fish. Environmental contaminant levels were measured in blood samples collected from the study participants. As well, nutritional and social benefits associated with consumption of Great Lakes fish were examined.

In a study by Kearney and others done in 1992-93 (Kearney and others 1999), blood levels of PCBs in men and women between Great Lakes fish eaters and non-fish eaters were compared for Mississauga and Cornwall combined. For male fish eaters the median level was 5.5 µg/L, for male non-fish eaters it was 3.9 µg/L. For women fish eaters and non-fish eaters the median levels were 3.4 and 3.2 µg/L. These differences were statistically significant for men only. Relative to fish eaters and families on the North Shore of the St. Lawrence River (Dewailly and others) (geometric mean 35.2 µg/L) and Quebec Inuit (Sante Quebec 1994) (geometric mean 16.1 µg/L), these values are low. Nonetheless, there are uncertainties surrounding our knowledge of potential long term health effects of low level exposure to PCBs.

Total mercury levels measured in the same participants were also low; the median levels for male Great Lakes fish eaters and non-eaters were 2.65 and 1.70 µg/L, respectively. Median levels for female Great Lakes fish eaters and non-eaters were 2.10 and 1.45 µg/L, respectively. Levels were generally at the lower end of the "normal acceptable range" (less than 20 µg/L) as defined by the Medical Services Branch of Health Canada and based on WHO guidelines. (Indian and Northern Affairs Canada 1997).

Hanrahan and others (1999) corroborated previous findings relating frequent Great Lakes sport fish consumption to a higher body burden for PCBs and DDE. The study examined relationships between demographic characteristics, Great Lakes sport fish consumption, PCB, and DDE body burdens. The blood serum PCB and DDE levels in a large cohort (538) of sport fish consumers for Lakes Michigan, Huron and Erie were significantly higher than in reference groups. Body burdens varied by exposure group, gender, and Great Lake. Years of consuming Great Lakes fish was the most important predictor of PCB levels, while age was the best predictor of DDE levels.

Falk and others (1999) examined fish consumption habits and demographics in relation to serum levels of dioxin, furan, and coplanar PCB congeners in one hundred subjects. Body burdens varied by gender and lake (Michigan, Huron, and Erie). Between-lake differences were consistent with fish monitoring data. Consumption of lake trout and salmon was a significant predictor of coplanar PCBs. Consumption of lake trout was also a significant predictor of total furan levels. Fish consumption was not significantly correlated with total dioxin levels.

5.2.3.2 Health Effects

Developmental, reproductive, neurobehavioral or neurodevelopmental, and immunologic effects of exposure to lipophilic pollutants (i.e. organochlorines) have been examined in studies conducted within the Great Lakes basin and outside the basin. The following are selected studies which have reported an association between exposure through sport fish consumption and these outcomes.

Developmental effects in the form of a decrease in gestational age and low birth weight have been observed in a Lake Michigan Maternal Infant Cohort exposed prenatally to PCBs (Fein and others 1984). These findings have also been observed in offspring of women exposed to PCBs occupationally in the manufacture of capacitors in New York (Taylor and others 1989).

Reproductive effects have also been reported. Courval and coworkers (1997, 1999) examined couples and found a modest association in males between sport-caught fish consumption and the risk of conception failure after trying for at least 12 months. Studies of New York state anglers have not shown a risk of spontaneous fetal death due to consumption of fish contaminated with PCBs (Mendola and others 1995), nor an effect on time-to-pregnancy among women in this cohort (Buck and others 1997).

Neurobehavioral or neurodevelopmental effects have been documented for exposure to persistent toxic substances in newborns, infants, and children of mothers consuming Great Lakes fish. Early investigations of the Lake Michigan Maternal Infant Cohort revealed that newborn infants of mothers consuming >6.5 kg/year of Lake Michigan fish had neurobehavioral deficits of depressed reflexes and responsiveness, when compared to non-exposed controls (Jacobson and others 1984). The fisheating mothers consumed an average of 6.7 kg of Lake Michigan contaminated fish per year, equal to 0.6 kg or 2 to 3 salmon or lake trout meals/month. Prior to study admission, exposed mothers were required to have fish consumption that totaled more than 11.8 kg over a 6-year period. Subsequent studies of the Michigan Cohort have revealed neurodevelopmental deficits in short-term memory at 7 months (Jacobson and others 1985) and at 4 years of age (Jacobson and others 1990b), and also growth deficits at 4 years associated with prenatal exposure to PCBs (Jacobson and others 1990a). A more recent investigation of Jacobson's Michigan Cohort has revealed that children most highly exposed prenatally to PCBs showed IQ deficits in later childhood (11 years of age) (Jacobson and Jacobson 1996). Highly exposed children received prenatal PCB exposure equal to at least 1.25 µg/gram (ppm) in maternal milk, 4.7 ng/milliliter (ppb) in cord serum, or 9.7 ng/milliliter (ppb) in maternal serum. The authors attributed these intellectual impairments to in utero exposure to PCBs.

The Oswego Newborn and Infant Development Project examined the behavioral effects in human newborns of mothers who consumed Lake Ontario fish that were contaminated with a variety of PBT chemicals. These infants were examined shortly after birth (12 to 24 and 25 to 48 hours). Lonky and others (1996) found that women who had consumed >40 PCB-equivalent pounds of fish in their lifetime had infants who scored more poorly in a behavioral test (Neonatal Behavioral Assessment Scale) than those in the low-exposure (<40 PCB-equivalent pounds of fish) or control group. In a follow-up study, Stewart and others (1999), concluded that the most heavily chlorinated and persistent PCB homologues were elevated in the umbilical cord blood of infants whose mothers ate Great Lakes fish. The concentration was significantly dependent on how recently the fish were consumed relative to pregnancy. A further study attempting to relate the level of PCBs to scores in infants is underway.

Mergler and coworkers (1997) reported early nervous dysfunction in adults who consumed St. Lawrence River fish. Initial testing for neurotoxic effects were not observed by Schantz and coworkers (1999) in an elderly adult population (i.e., ≥50 years) of Lake Michigan fisheaters with exposure to PCB and DDE. This study is ongoing.

Immunologic effects have also been reported. Smith's study (1984) demonstrated that maternal serum PCB levels during pregnancy were positively associated with the type of infectious diseases that infants developed during the four months after birth. In addition, incidence of infections has been shown to be associated with the highest fish consumption rate for mothers (i.e., at least three times per month for three years) (Swain 1991, Tryphonas 1995).

Other health effects have been documented with PCB exposure. Elevated serum PCB levels were associated with self-reported diabetes and liver disease in cohorts of Red Cliff and Ojibwa Native Americans (Dellinger and others 1997, Tarvis and others 1997). Fischbein and coworkers (1979) found that workers exposed to a variety of PCB Aroclors reported joint pain.

A summary of health effects studies inside and outside the Great Lakes basin can be found in the recent paper published by Johnson and coworkers (1998). A summary of the health effect of methyl mercury can be found in a recent publication by Mahaffey (1999).

5.2.3.3 Future Research Needs

The potential long term effects of exposure to PBT chemicals have implications for future generations, and thus should remain a priority for public health investigation. Future research needs include:

1. *Need to continue to assess the role of PBT chemicals on neurobehavioural and neurodevelopmental effects*

2. *Need to improve the assessments of chemical mixtures*

Within our present state-of-knowledge, the human research demonstrating health effects from consumption of contaminated fish can be said to be relatively sound. Although these studies, in most cases, have made associations between a single contaminant detected in fish and the body burden or health effect, detections of multiple chemicals have been found in Great Lakes fish (Humphrey 1988; Dellinger and others 1996). Our present state-of-knowledge is vastly limited in identifying the subtle effect of multiple chemicals detected, even at low levels, in contaminated fish. For this reason, research is needed to clearly delineate whether a synergistic or additive effect occurs with multiple chemicals, and with a combination of chemicals having similar properties.

3. *Need to better assess the role that endocrine disruption may play in human heath effects, example reproductive health.*

Research has demonstrated that many of the contaminants found in fish from Lake Superior and other Great Lakes have been shown to adversely affect the endocrine system in fish and wildlife and laboratory animal studies. An environmental endocrine disruptor is ". . . an exogenous agent that interferes with the synthesis, secretion, transport, binding, action, or elimination of natural hormones in the body that are responsible for the maintenance of homeostasis, reproduction, development, and/or behavior" (EPA 1997c). Some of the known endocrine disrupting chemicals include atrazine, chlordanes, DDT and metabolites, dieldrin, dioxins and furans, PCBs, and toxaphene (EPA 1997c). These are contaminants that have been detected in Lake Superior and other Great Lakes. Other substances, detected in the Great Lakes, are considered probable endocrine disruptors. These include cadmium, hexachlorobenzene, lead, mercury, and mirex. Although research continues on reproductive (Buck and others 1999; Courval and others 1999) and other effects that may be associated with exposure to endocrine disrupting chemicals, our knowledge about these substances in humans remains limited. Epidemiologic research needs to quantify the magnitude of exposures and effects of substances considered to be endocrine disruptors (EPA 1997c). Since endocrine disrupting chemicals, such as PCBs and DDT, have been detected simultaneously in fish, their effect as chemical mixtures also requires investigation.

4. *PCB Congeners*

Further human research is needed to identify the specific PCB congeners associated with adverse human health effects. The use of the capillary column gas chromatography, starting in the late 1980s and early 1990s, has enabled laboratories to identify the 209 PCB congeners (Communication with Virlyn Burse 2000). Stewart and coworkers (1999) found that the most heavily chlorinated PCB homologues (i.e., 7 or 8 chorines per PCB biphenyl ring) were significantly higher in the fetal cord blood of infants whose mothers had consumed Lake Ontario fish. These highly chlorinated and persistent PCB homologues were also detected in fish from Lake Ontario. Animal studies have supported this observation that highly chlorinated PCBs are responsible for adverse health effects. Congener-specific studies will help to identify those congeners that are most likely to adversely influence human health and require public health intervention.

5. Biologic Markers
Research has demonstrated that exposure on a regular basis to high levels of fish consumption can result in high body burdens of lipophilic contaminants such as PCBs and that the body burdens of these contaminants remains relatively constant in the body even after exposure cessation. For the goal of prevention, improved markers are needed to indicate biologic changes that predict health impairment or disease (NRC 1989) and the preclinical signs of disease (De Rosa and Johnson 1996). Currently funded research projects are examining body burdens of contaminants in serum, reproductive problems related to conception, and other health-related problems, that will be instrumental in identifying early warning signs requiring intervention. However, the biologic markers of exposure and effect often lack the precision to identify those who have an exposure, impairment, or disease, and those who do not. For this reason, additional research is needed to develop biologic markers that clearly identify the concentration of contaminants and the point in the human physiological process beyond which lasting adverse health effects will be observed.

5.2.3.4 Conclusion

For PBT chemicals, the current weight of evidence regarding human health effects is sufficient to support continued reductions in the levels of PBT chemicals in the environment. While public health advisories and other guidelines can be followed to protect human health from current environmental exposures, continued reductions in the level of PBT chemicals in the environment, both globally and regionally, are ultimately the most effective long-term solution to minimizing the health risks to the Lake Superior basin population. In addition, a shift in priorities is now needed to remediation, prevention, intervention, and collaborative activities, including the work of LaMPs.

5.3 HUMAN HEALTH INDICATORS TO MEASURE PROGRESS

Indicators and Targets for the Human Health Objectives were proposed in the LaMP’s Ecosystem Principles and Objectives Discussion Paper. They include:

Table 5-4 Proposed Human Health Indicators for Lake Superior

Human Health Indicator	Short Description
Environmental Health Indicators	Monitor for contaminants, including radionuclides, in various environmental media, including food originating in the Great Lakes basin (e.g. fish and wildlife), drinking water, recreational water, and air. Levels would be compared to current guidelines and standards.
Body Burden Indicator	Concentration of toxic contaminants in human tissue to serve as an indicator of exposure.
Health Effects Indicator	Traditional indicators such as cancer and birth defects.
Public Perception Indicator	Indicator to gauge if people are not using certain resources because of perceived health risks.

At the human health sessions of the Lake Superior LaMP Monitoring Workshop (October 25-27, 1999, Sault Ste. Marie, Ontario), it was agreed that radionuclides are not an issue for Lake Superior, and therefore the radionuclide indicator was dropped from the proposed list for indicator development. It was also agreed that sediments and soils needed to be added to the list in terms of considerations for indicator development, since they are indirect routes of exposure to PBT chemicals in terms of bioaccumulation through the food chain. In addition, it was agreed that the air pollution indicator needed to also make reference to atmospheric deposition so that PBT chemicals would also be considered.

Health Canada has developed a preliminary suite of health-related indicators as per the above list. These are published in the document *Health-Related Indicators for the Great Lakes basin Population: Numbers 1-20* (Health Canada 1998b), and they were also presented at the State of the Lakes Ecosystem Conference (SOLEC) 1998.

5.4 CONCLUSIONS AND IMPLEMENTATION PLAN

For persistent bioaccumulative toxic chemicals, the current weight of evidence regarding human health effects is sufficient to support continued reductions in the levels of PBT chemicals in the environment. While public health advisories and other guidelines can be followed to protect human health from current environmental exposures, continued reductions in the level of persistent pollutants in the environment, both globally and regionally, are ultimately the most effective long-term solution to minimizing the health risks to the Lake Superior basin population.

Although progress has been made in defining the health threat from Great Lakes pollutants (including Lake Superior pollutants), important issues remain requiring our diligent effort. To protect human health in the Lake Superior basin, actions must continue to be implemented on a number of levels. The Great Lakes Water Quality Agreement, under the Research and Development annex, calls for ". . . develop[ing] approaches to population-based studies to determine the long-term, low-level effects of toxic substances on human health" (IJC 1994). For the public health arena, there are a number of issues that will help to identify these long-term, low-level health effects. Research in these areas will provide a more comprehensive view of the threat to human health from environmental contaminants, and enable public health agencies to utilize this knowledge to protect the public health more effectively. In addition, a shift in priorities is now needed to remediation, prevention, intervention, and collaborative activities, including the work of LaMPs. In particular, contaminant levels monitoring in environmental media and in human tissues is an activity in particular need of support, to better quantify the extent of exposure. Health risk communication is also a crucial component to protecting and promoting human health in the basin. The Lake Superior LaMP can play a key role in informing people about human health impacts of environmental contaminants and what they can do to minimize their health risks. This includes linking people to information that is packaged in a variety of ways and targeted to a range of audiences, to enable individuals to make informed choices about their health.

Implementation: Programs targeted at Human Health and Environmental Contaminants in the Great Lakes basin Numerous Federal, State, Provincial and local government agencies, as well as environmental non-government organizations and communities are actively involved in the protection and promotion of human health as it relates to the environment. In particular, two Federal programs are in place to specifically address human health in the Great Lakes basin. In the U.S., the Agency for Toxic Substances and Diseases Registry addresses human health in the Great Lakes basin through its Great Lakes Human Health Effects Program. In Canada, Health Canada's Great Lakes Health Effects Program is addressing human health issues as they relate to the Great Lakes basin ecosystem. These programs are described in detail in Addendum 5-A.

Progress continues to be made to reduce the risk to health from exposure to environmental contaminants in the Great Lakes basin.

The following is a summary of the specific conclusions made in this chapter for drinking water, recreational water, fish/food consumption, and PBT chemicals.

5.4.1 Drinking Water Quality

Over time, public water systems, have been found to supply drinking water of good quality. Monitoring, and corrective measures to reduce and eliminate levels of contaminants in treated water are essential components in assuring the safety of drinking water supplies. As the population grows, and as more people rely on the drinking water supply and participate in recreational activities such as swimming, these control measures must be adequate to reduce the risk from exposure to microbes in Great Lakes waters (Health Canada 1997). Ultimately, however, source water protection (protection of the raw waters) is the key to maintaining the good quality of drinking water supplies.

5.4.2 Recreational Water Quality

Pollution controls and remediation, such as reducing combined sewer overflows, and improvements in sewage treatment, have continued to improve water quality in many areas of the Great Lakes basin in recent years. Long term planning for remediation of microbial contaminants in recreational water needs to include identification of sources of contamination, determination of which sources can be remediated and the costs involved, and timelines for implementation (Health Canada 1998b, Lake Erie LaMP 1999, Bartram and Rees 2000, U.S. EPA 1998a). Although it may not be feasible to eliminate exceedances of microbial levels completely in recreational use waters, it is expected that as sources continue to be remediated, exceedances and the threat to human health will continue to decline (Lake Erie LaMP 1999; U.S. EPA 1998a).

5.4.3 Fish Consumption

Diet contributes over 95 percent of the PBT chemical intake for the general population, with drinking water, recreational water, and air constituting very minor exposure routes. Consequently, the approach by various public health agencies has been to focus on groups at higher risk of exposure to persistent toxic substances from Great Lakes Sources, such as high consumers of sport fish. Because of the presence of PCBs, organochlorine insecticides, mercury, and other chemicals found in fish from the Lake Superior basin, fish advisories are issued that recommend restrictions on fish consumption, with tighter restrictions (in some cases to the point of complete elimination) of fish from the diet of pregnant women, women of childbearing age and children. In communicating health risk information to fish consumers, it is important to remember that fish are also a good source of low-fat protein, and that the activity of sport fishing has social and cultural benefits.

There are several areas that require future research and activity regarding fish consumption: 1)surveillance to evaluate how much fish people eat and carry out biomonitoring to determine actual tissue levels, particularly within sensitive populations, 2) incorporation of quantitative benefits of fish consumption into the risk assessment protocol for developing fish consumption advice 3) development of a meaningful indicator on time trends in how safe fish are to eat, 4) awareness of fish advisories needs to be increased, and 5) the effectiveness of fish advisories needs to be improved.

5.4.4 Persistent Bioaccumulative Toxic Chemicals

Since the 1970s, there have been steady declines in many persistent bioaccumulative toxic (PBT) chemicals in the Great Lakes Basin, leading to declines in levels in human tissues, for example, lead in blood, and organochlorine contaminants in breast milk. This translates into a reduced risk to health for these contaminants. However, PBT chemicals, because of their ability to bioaccumulate and persist in the environment, continue to be a significant concern in the Lake Superior Basin. Therefore, the continued remediation and prevention strategies promoted by the Lake Superior LaMP Chemicals Document (need correct title and reference) should be prioritized along with public health advisories and other intervention activities for the protection of human health from current environmental exposures.

As stated earlier, demonstrating health effects in humans from chronic, low-level exposure to PBT chemicals typically encountered in the Great Lakes region poses a challenge for researchers. For example, human epidemiological studies are limited in their ability to separate health effects attributable to contaminant exposures from those related to other known health factors like smoking, alcohol intake and general health status. Despite these limits, neurodevelopmental and reproductive effects have been reported in some studies of human populations in the Great Lakes basin. In addition, developmental effects have been observed in wildlife and laboratory studies of PBT chemicals. Therefore, in defining the threat to human health from exposure to contaminants in the Lake Superior basin, a weight of evidence approach is often used, where the overall evidence from wildlife studies, experimental animal studies, and human studies is considered. These human and wildlife studies are sufficient to suggest that human health is at risk from exposure to PBT chemicals. The potential long-term effects have implications for future generations and thus should remain a priority for public health investigation.

5.4.5 Implementation Plan/Action Matrix

To protect human health in the Lake Superior basin, actions must continue to be implemented on a number of levels. Action items targeted at monitoring, research and protection of human health of Lake Superior basin residents are included in Table 5-5 below and the Lake Superior LaMP 2000 Action Matrix. In particular, contaminant levels monitoring in environmental media and in human tissues is an activity in particular need of support, to better quantify the extent of exposure. Health risk communication is also a crucial component to protecting and promoting human health in the basin. The LaMP can play a key role in informing people about human health impacts of environmental contaminants and what they can do to minimize their health risks. This includes linking people to information that is packaged in a variety of ways and targeted to a range of audiences, to enable people to make informed choices about their health.

For persistent bioaccumulative toxic chemicals, and in particular the PBT chemicals on Lake Superior’s zero discharge list, the current weight of evidence regarding human health effects is sufficient to support continued reductions in the levels of PBT chemicals in the environment. While public health advisories and other guidelines can be followed to protect human health from current environmental exposures, the continued reductions in the level of persistent pollutants in the environment are the most effective long-term solution to minimizing the health risks to people.

Table 5-5 Action/Implementation Plan Matrix

Description	Project Lead	Funding Status
Drinking Water		
Assess sources of drinking water. • For the U.S., EPA and all the Lake Superior States, tribes and local water utilities have adopted a Source Water Protection Protocol for use in source water assessments to be conducted by 2003. The standardized protocol for conducting assessments of public drinking water supplies will delineate source areas and assess significant potential sources of contamination in order to protect water supplies and inform beach managers. • In Canada (Ontario), assessment of drinking water supply sources is done by the Ontario Drinking Water Surveillance Program and reported to the public.	U.S. states working with U.S. EPA and local communities Ontario Drinking Water Surveillance Program	A A
Protect drinking water sources. This would include specific actions such as: wellhead protection plans and protection plans for water supply intakes on Lake Superior	U.S. states working with U.S. EPA and local communities; Health Canada/Ontario/ local communities	A
Raise awareness and improve the outreach of drinking water monitoring information to the general population B Confidence Reports, U.S.; Drinking Water Surveillance Program, Ontario.	U.S. and Canadian Water Systems; state/provincial and federal health and environmental agencies; and local governmental agencies	A & B
Promote epidemiological research (exposure and health effects) on drinking water borne diseases in the Great Lakes and for the Lake Superior basin in particular. This should include an evaluation on public vs. private sources.	Funded research from NIEHS, U.S. EPA, Health Canada and academic researchers	A & B (funding needs to be targeted towards the Great Lakes)
Continue to research the implications of aluminum and chlorination disinfection by-products on human health and promote the development of guidelines for water treatment to minimize any risk to health that may exist.	U.S. EPA, Health Canada/Ontario	A
Improve the identification/diagnosis and promote the reporting of water borne disease incidences to help in	U.S. CDC, state and local health	

Table 5-5 Action/Implementation Plan Matrix

Description	**Project Lead**	**Funding Status**
response to disease outbreaks (such as in Milwaukee), improving information for epidemiological studies and for tracking trends over time (indicator).	departments; Province of Ontario and Local Health Units	C
Research and development of technologies and methods for the detection and treatment of Giardia, Cryptosporidium and other parasites in drinking water to protect human health.	U.S. federal and state health agencies, U.S. EPA; Health Canada	A & B
Promote ambient monitoring of Lake Superior drinking water intakes, and tributaries that can potentially degrade water quality at these intakes, and storage of data in electronic databases. Microbiological and turbidity monitoring should be included in the monitoring program.	IJC Indicator Implementation Task Force; U.S. EPA OGWDW; EPA GLNPO; Great Lakes Commission	A & B (In Canada this is done and reported U.S. may be done but not required to be reported.)
Recreational Water		
Continue to promote and expand the U.S. BEACHs surveillance program and corollary programs for the Canadian shoreline. This would include outreach to local governments along the Lake Superior shoreline for their involvement. In parallel a Lake Superior indicator of recreational water quality that includes microbial data supplemented by beach postings should continue to be developed.	U.S. EPA, Health Canada with state/provincial and local governments.	A
Continue the development of rapid sampling technologies and techniques for microbial and viral contamination and promote the dissemination and use of the instrument and sampling methods to local governments along the Lake Superior shoreline.	U.S. EPA BEACHs program, Health Canada, Ontario, state and local governments	A & B
Promote epidemiological research on water borne diseases in the Great Lakes and for the Lake Superior basin in particular. This should also include research on the health implications of interstitial bathing waters, CSO/SSO discharges and inhalation of water spray.	Funded research from NIEHS, U.S. EPA, Health Canada and academic researchers	A & B
Fish Consumption		
Research the health benefits of fish consumption to better quantify those benefits for use in risk assessment for developing fish consumption advice.	U.S. EPA/OST	B & C
Develop an indicator for fish consumption. Promote the reporting of contaminant levels in edible portions of fish collected by State Agencies responsible for fish consumption advisories. Indicator would track these levels over time.	State health and natural resource agencies, U.S. EPA, Health Canada, Ontario	A & B

Table 5-5 Action/Implementation Plan Matrix

Description	Project Lead	Funding Status
Increase awareness, use and effectiveness of fish advisories in the Lake Superior populations targeting sensitive populations (minorities, women of child bearing age, immigrants, the elderly, etc.)	State and province government agencies, U.S. EPA, Health Canada, local governments	A & B
• U.S. EPA Study - Consortium for Improving the Effectiveness of Fish Consumption Advisories for Mercury Contaminated Sport Fish/Phase I - The states of Wisconsin and Maine received a grant from the U.S. EPA to assess mercury fish advisory awareness and fish consumption among women of childbearing age. As part of the project, focus groups were conducted in WI and ME to determine the channels by which women receive health information, obtain information about how they prefer to receive advisory information, and determine what they view as the central risk message that needs to be communicated. Childbearing age women from 12 states including WI and MN (in the Lake Superior basin) were contacted randomly by phone and surveyed about fish consumption habits, including commercial and sport-caught fish; awareness of the fish advisory; the modes by which they received the message; and whether they follow the advice. These women were also requested to send in a hair sample for mercury analysis. The results of this project will be available this year.	U.S. EPA/State of Wisconsin	A
• ATSDR grant to Consortium for the Health Assessment of Great Lakes Fish Consumption This is an ongoing project to conduct a Great Lakes basin wide outreach program to distribute sport-fish advisory materials to women of childbearing age and to host a conference to establish a forum for exchange of information on successful distribution of the sport fishing advisory to women of childbearing age and other high risk populations. The Consortium of Great Lakes states developed outreach materials for women of childbearing age and minority groups which are being utilized by seven of the eight Great Lakes states (Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Wisconsin). These outreach materials such as posters and recipe cards are being adapted by each of the states for their specific needs, and are being distributed at women and children's clinics, health fairs, state fairs, and fishing shows to increase health advisory awareness.	State of Wisconsin	A
GLIFWC Mercury in Walleye GIS Maps - Maps showing color coded inland lakes in MI, WI, and MN based on mercury content in walleye.		A

Table 5-5 Action/Implementation Plan Matrix

Description	Project Lead	Funding Status
Analysis of mercury in hair from MN Lake Superior basin residents	(Add on to UND/EERC project - use U.S. EPA LSBP human health committee project $?)	B
Screen fish from U.S. Lake Superior basin for suite of OCCs - as PCBs decline other OCCs will become an issue		B
Exposure and Health Effects Research		
Promote exposure, outcome and epidemiological research for PBT chemicals in the Great Lakes and specifically within the Lake Superior basin. This research should include the five needs for the future listed in Section 5.2.	NIEHS, U.S. EPA, Health Canada, Environment Canada, State, Provincial and Local Health departments	A & B
• <u>Fish Consumption Study</u> - Tracking tribal members' fish consumption. Several tribes are within the Lake Superior basin.	GLIFWC	A
• <u>Contaminant testing of commercially-sold Lake Superior fish</u> - Analyzed fillets from four commercially harvested species of fish for mercury, PCBs, and organochlorine pesticides. The study evaluates the effects of commercial processing methods (i.e., trimming and smoking) on contaminant concentrations.	GLIFWC	A
• <u>Fish Consumption Survey: Minnesota and North Dakota</u> - Residents of North Dakota and Minnesota, including some Lake Superior residents, will be surveyed to evaluate fish consumption patterns that can be used to estimate population exposure to mercury. This is a one year project. Survey design will begin in January 2000 and survey implementation in summer 2000.	DOE, utility industry, State of Minnesota, State of North Dakota sponsored project - University of North Dakota Energy & Environmental Research Center (EERC)	A
• <u>EPA-CEM funded project - Grand Portage/Fond du Lac Fish Consumption Advice</u> - Fish consumption advice will be developed for the Grand Portage Band of Chippewa and Fond du Lac Band of Lake Superior Chippewa. Due to a greater reliance on fish in their diets, the bands are potentially more exposed to bioaccumulative contaminants found in some fish. The project will include qualitative exposure assessment, fish sampling (including Lake Superior and tributaries), chemical analysis, advisory development and outreach (particularly to women of child-bearing age.)	U.S. EPA/MDH	A
• <u>Shoreline Survey</u> - In a recent Health Canada study carried out in five Areas of Concern in the lower Canadian Great Lakes (Dawson 2000), 4,637 shoreline fishers were interviewed. The demographic data show that there is no such thing as a "typical" fisher. People who like to fish come from different cultural backgrounds, are different ages and have different occupations. A report of the results is expected to be available by mid-year 2000.	Health Canada	A
• <u>Great Lakes Fish Eater Study</u> - A concurrent project, the Great Lakes Fish Eaters Study (not yet released) has taken a more in-depth look at exposure to environmental contaminants in people eating large amounts of Great Lakes fish. Environmental contaminant levels were measured in blood samples collected from the study participants. As well, nutritional and social benefits associated with consumption of Great Lakes fish were examined	Health Canada	A

Table 5-5 Action/Implementation Plan Matrix

Description	Project Lead	Funding Status
examined. • ATSDR has awarded 10 research grants to study adverse human health effects from consumption of contaminated Great Lakes fish. These research activities and associated findings will be coupled with state and local public health activities designed to prevent adverse health effects in identified at-risk populations.	ATSDR	A
Other		
Development of a Human Health Resource Home Page for the Great Lakes with pages specifically oriented towards human health issues in the Lake Superior basin	LaMP HH Committee, U.S. EPA, Health Canada, states and provinces working with the Great Lakes Commission and other LaMP partners	A
Assessment of social dimensions of health in the Lake Superior basin. Identify references available, and the need to address the social dimensions of health, further to the WHO definition of health.	LaMP HH Committee working with LaMP Partners. Health Canada, U.S. EPA	B
Literature review of wildlife consumption issues.		B
Need a better understanding of the chemical reactions and interactions in the transition zone between groundwater and surface water, to facilitate quantitative risk assessment of the potential effects of PBT contaminated sediments.		C

5.5 GLOSSARY AND ACRONYMS

Beneficial Uses - human health-related beneficial uses of Lake Superior include: fishable (We can all eat any fish); Drinkable (Treated drinking water is safe for human consumption; We can all drink the water); and Swimmable (All beaches are open and available for public swimming; We can all swim in the water).

Beneficial Use Impairments - Use impairments such as restrictions on fish and wildlife consumption and beach closings prevent populations in the Lake Superior basin from fully enjoying the beneficial uses of the lake.

Bioaccumulation - a generic term that refers both to biomagnification and bioconcentration

Bioconcentration - is the accumulation of a chemical in an organism from exposure to its environment

Biomagnification - a cumulative increase in the concentration of a persistent substance in successively higher trophic levels of the food chain

Chemical Contaminants - include naturally occurring chemicals and anthropogenic or synthetic chemicals

Critical Pollutants - for Lake Superior, nine critical pollutants have been targeted for zero discharge and virtual elimination.

Ecosystem - the interacting complex of living organisms and their non-living environment (U.S. EPA / Govt of Canada 1995)

Environmental Contaminants - substances foreign to a natural system or present at unnatural concentrations. They are unwanted substances that have entered the air, food, water or soil. They may be chemicals, living things, such as bacteria or viruses, or the products of radioactivity. Some contaminants are created by human (e.g. industrial) activities while others are the result of natural processes (Health Canada, The Health and Environment Handbook for Health Professionals 1998).

Exposure - any contact between a substance and an individual who has touched, breathed or swallowed it.

Exposure Pathways - the pathway a contaminant may take to reach humans or other living organisms; pathways include drinking water, recreational water and fish/food consumption (Health Canada 1998e).

Exposure routes - The three major routes that chemical and microbial pollutants enter the human body are by ingestion (water, food, soil), inhalation (airborne), and dermal contact (skin exposure).

Food Web - the process by which organisms in higher trophic levels gain energy by consuming organisms at lower trophic levels. Humans are at the highest level of many food webs (U.S. EPA / Government of Canada 1995, Health Canada 1998e)

Guideline - a recommended limit for a substance or an agent intended to protect human health or the environment that is not legally enforceable (Health Canada 1998e)

Great Lakes basin Ecosystem - the interacting components of air, land, water and living organisms, including humans, within the drainage basin of the St. Lawrence River at or upstream from the point at which this river becomes the international boundary between Canada and the United States (IJC 1987).

Human health - “a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity” (World Health Organization 1984).

Microbial Contaminant - micro-organisms (e.g. bacteria, viruses, and protozoa such as cryptosporidium) that can cause disease

Persistent Bioaccumulative Toxic Chemicals - These chemicals do not break down easily, persist in the environment, and bioaccumulate in biota and animal and human tissues

Public Health Agencies - for Lake Superior, includes the State Departments of Health for Michigan, Minnesota, and Wisconsin; the Ontario Ministry of Health (Provincial); Health Canada (Federal); U.S. Agency for Toxic Substances and Diseases Registry (ATSDR, Federal); U.S. Centers for Disease Control (Federal); Public Health Units (municipalities in Ontario); Public Health Departments (State counties).

Standard - a legally enforceable limit for a substance or an agent intended to protect human health or the environment. Exceeding the standard could result in unacceptable harm. (Health Canada 1998e).

Toxicological Profiles - Toxicological Profiles have been prepared by the U.S. Agency for Toxic Substances and Disease Registry (ATSDR), “for hazardous substances which are most commonly found at facilities on the CERCLA National Priorities List and which pose the most significant potential threat to human health, as determined by ATSDR and the Environmental Protection Agency” (U.S. Department of Health and Human Services 1992).

Toxic Substance - a substance which can cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological or reproductive malfunctions or physical deformities in any organism or its offspring, or which can become poisonous after concentration in the food chain or in combination with other substances (IJC 1987).

Weight of evidence approach - the weight of evidence approach considers all high-quality scientific data (i.e. the overall evidence) on adverse health effects from wildlife studies, experimental animal studies, and human studies in combination, toward hazard identification and in weighing the actual and potential adverse health effects of environmental contamination in human populations.

Acronyms

AFRI - Acute Febrile Respiratory Illness

BUIA - Beneficial Use Impairment Assessment

CCL - U.S. EPA Contaminated Candidates List

CSO - Combined Sewer Overflow

GLWQA - Great Lakes Water Quality Agreement

IJC - International Joint Commission

LaMPs - Lakewide Management Plans

MAC - Maximum Acceptable Concentration (used for Canadian guidelines)

MCL - Maximum Concentration Limit (used for U.S. standards and guidelines)

NPDWR - National Primary Drinking Water Regulations (U.S.)

PBT Chemicals - persistent, bioaccumulative toxic chemicals

PCBs - polychlorinated biphenyls - a class of persistent organic chemicals that bioaccumulate (U.S. EPA / Govt of Canada 1995).

SSO - Sanitary Sewer Overflow

SWPP - Source Water Protection Project

TDI - Total Daily Intake

TMDL - Total Maximum Daily Load

TOC - Total Organic Carbon

5.6 INTERNET INFORMATION RESOURCES AND FURTHER READING LAKE SUPERIOR HUMAN HEALTH ISSUES

5.6.1 General Internet Resources and Readings

United States
U.S. Environmental Protection @AGENCY Home Page
http://www.epa.gov/

U.S. EPA Great Lakes National Program Office
http://www.epa.gov/glnpo

U.S. EPA Region 5
http://www.epa.gov/

U.S. Center for Disease Control
http://www.cdc.gov/

U.S. Agency for Toxic Substances Disease Registry
http://www.atsdr.cdc.gov/

U.S. ATSDR Great Lakes Health Effects Program
http://www.atsdr.cdc.goc/grlakes.html

States
Michigan Department of Community Health
http://www.mdch.state.mi.us/

Minnesota Department of Health
http://www.health.state.mn.us/

Wisconsin Department of Health
http://www.dhfs.state.wi.us/

Canada
Health Canada General Home Page
http://www.hc-sc.gc.ca/

Health Canada, Environmental Health Program Home Page
http://www.hc-sc.gc.ca/ehp/ehd/

Province
Ontario Ministry of Health
http://www.gov.on.ca/health/index.html

Readings

ATSDR (Agency for Toxic Substances and Disease Registry). 1993. Aldrin/Dieldrin Fact Sheet. Atlanta, Georgia: U.S. Department of Health and Human Services.

ATSDR (Agency for Toxic Substances and Disease Registry). 1995. Chlordane Fact Sheet. Atlanta, Georgia: U.S. Department of Health and Human Services.

ATSDR (Agency for Toxic Substances and Disease Registry). 1999. Chlorinated Dibenzo-p-Dioxins Fact Sheet. Atlanta, Georgia: U.S. Department of Health and Human Services.

ATSDR (Agency for Toxic Substances and Disease Registry). 1995. DDT, DDE, and DDD Fact Sheet. Atlanta, Georgia: U.S. Department of Health and Human Services.

ATSDR (Agency for Toxic Substances and Disease Registry). 1997. Hexachlorobenzene Fact Sheet. Atlanta, Georgia: U.S. Department of Health and Human Services.

ATSDR (Agency for Toxic Substances and Disease Registry). 1999. Mercury Fact Sheet. Atlanta, Georgia U.S. Department of Health and Human Services.

ATSDR (Agency for Toxic Substances and Disease Registry). 1997. Polychlorinated Biphenyls Fact Sheet. Atlanta, Georgia: U.S. Department of Health and Human Services.

ATSDR (Agency for Toxic Substances and Disease Registry). 1998. Polychlorinated Biphenyls Toxicological Profile (updated draft). Atlanta, Georgia: U.S. Department of Health and Human Services.

ATSDR (Agency for Toxic Substances and Disease Registry). 1997. Toxaphene Fact Sheet. Atlanta, Georgia: U.S. Department of Health and Human Services.

Health Canada. 1998. Jackfish Bay Area of Concern: Health Data and Statistics for the Population of the Township of Terrace Bay. (1986-1992)

Health Canada. 1998. Nipigon Bay Area of Concern: Health Data and Statistics for the Population of the Region. (1986-1992)

Health Canada. 1998. Peninsula Harbour Area of Concern: Health Data and Statistics for the Population of Marathon. (1986-1992)

Health Canada. 1998. Thunder Bay Area of Concern: Health Data and Statistics for the Population of the Region. (1986-1992)

Health Canada. 1997. State of Knowledge Report on Environmental Contaminants and Human Health in the Great Lakes basin.

International Joint Commission. Revised Great Lakes Water Quality Agreement of 1978 as Amended by Protocol Signed November 18, 1987. Reprint February, 1994.

U.S. EPA and Government of Canada, 1995. The Great Lakes: An Environmental Atlas and Resource Book.

Johnson, B.L., H.E. Hicks, D.E. Jones, W. Cibulas, A. Wargo and C. T. De Rosa. 1998. Public Health Implications on Persistent Toxic Substances in the Great Lakes and St. Lawrence basins. Journal of Great Lakes Research. 24(2): 698-722.

5.6.2 Internet Resources and Further Readings for Air:

Canada
Air Pollution Health Effects Research Program in its Environmental Health Directorate
http://www.hc-sc.gc.ca/ehp/ehd/bch/air_quality.htm

Health Canada/Santé Canada. *Outdoor Air and Your Health: A summary of Research Related to the Health Effects of Outdoor Air Pollution in the Great Lakes basin. / L'atmosphère et votre santé: Résumé de la recherche relative aux effets sur la santé de la pollution atmosphérique dans le bassin des Grands Lacs*. (Bilingual/bilingue). Great Lakes Health Effects Program/Le programme <Les Grands Lacs: Impact sur la santé>, March/Mars 1996.

United States
EPA Office of Air and Radiation
http://www.epa.gov/oar/oarhome.html

U.S. EPA Health Effects Notebook for Hazardous Air Pollutants
http://www.epa.gov/ttn/uatw/hapindex.html

OSHA Indoor Air page:
http://www.osha-slc.gov/SLTC/indoorairquality/index.html

5.6.3 Internet Resources and Further Readings for Drinking Water:

Canada
Health Canada, 1999. Drinking Water Quality home page, at web site
http://www.hc-sc.gc.ca/ehp/ehd/bch/water_quality.htm

Ontario Ministry of Environment, Drinking Water Surveillance Program. This web site provides executive summaries describing the performance of municipal water treatment facilities monitored under DWSP, for the years 1996-97.
http://www.ene.gov.on.ca/envision/dwsp/index96_97.htm

United States
U.S. EPA Office of Ground Water and Drinking Water Home Page
http://www.epa.gov/safewater/about.html
http://www.epa.gov/OGWDW/wot/appa.html
http://www.epa.gov/ogwdwooo/hfacts.html

U.S. EPA, How Safe is my Drinking Water? Office of Ground Water and Drinking Water http://www.epa.gov/OGWDW/wot/howsafe.html

U.S. EPA, Current Drinking Water Standards - National Primary and Secondary Drinking Water Regulations. Office of Groundwater and Drinking Water web site at http://www.epa.gov/OGWDW/wot/appa.html

U.S. EPA, Consumer Confidence Reports. Fact Sheet. At web site http://www.epa.gov/safewater/ccr/ccrfact.html

USFDA Food borne Pathogenic Microorganisms and Natural Toxins Handbook Web Page http://vm.cfsan.fda.gov/~mow/chap24.html

U.S. Center for Disease Control. Cryptosporidiosis Fact Sheet. http://www.cdc.gov/ncidod/diseases/crypto/cryptos.htm

Readings
Wisconsin Department of Natural Resources, 1998. ACryptosporidium: " Risk to our Drinking Water." Fact Sheet. Available on WDNR web site at http://www.dnr.state.wi.us/org/water/dwg/Crypto.htm#what steps Revised June 1, 1998.

Health Canada, 1993. The Undiluted Truth about Drinking Water.

Health Canada, 1995. Great Lakes Water and Your Health: A summary of AGreat Lakes basin Cancer Risk Assessment: "Case-control Study of Cancers of the Bladder, Colon and Rectum"

Health Canada, 1998b. Health Canada Drinking Water Guidelines. It's Your Health Fact Sheet Series, May 27, 1997.

5.6.4 Internet Resources and Further Readings for Recreational Water

Canada
Health Canada, 1999. It's Your Health: Recreational Water Quality.

United States
U.S. EPA, Office of Water, EPA's BEACH Watch Program, 1999 Update

http://www.epa.gov/OST/beaches/update.html

U.S. EPA's BEACH Watch Program Homepage
http://www.epa.gov/OST/beaches/

U.S. EPA Office of Water, BEACH Watch Program Homepage.
http://www.epa.gov/OST/beaches/

U.S. EPA Office of Water, BEACH Watch Program. Local Beach Health Information.
http://www.epa.gov/OST/beaches/local/

Natural Resources Defense Council (NRDC). Testing the Waters - 1999 - A Guide to Water Quality at Vacation Beaches
http://www.igc.org/nrdc/nrdcpro/ttw/titinx.html

Health Canada. "It's Your Health" Series: Recreational Water Quality
http://www.hc-sc.gc.ca/ehp/ehd/catalogue/general/iyh/recwater.htm

5.6.5 Internet Resources and Further Readings for Fish/Food Consumption

Canada (Ontario)
Ontario Ministry of the Environment. Guide To Eating Ontario Sport Fish 1999 - 2000
http://www.ene.gov.on.ca/envision/guide/index.htm

United States
U.S. EPA Fish Consumption Advisory Information
http://www.epa.gov/OST/fish/

States
Michigan Department of Community Health. Michigan Fish Advisory
http://www.mdch.state.mi.us/pha/fish/index.htm

Minnesota Department of Natural Resources. Minnesota Fish Advisory
http://www.dnr.state.mn.us/lakefind/fca/index.html

Wisconsin Department of Natural Resources. Wisconsin Fish Advisory
http://www.dnr.state.wi.us/org/water/fhp/fish/advisories/

5.6.6 Internet Resources and Further Readings for Health Effects Information

ATSDR's Toxicological Profiles
http://www.atsdr.cdc.gov/toxpro2.html

ATSDR HAZDAT Database: Hazardous Materials and their Human Health Effects
http://atsdr1.atsdr.cdc.gov:8080/hazdat.html

ATSDR, Public Health Implications of Exposure to Polychlorinated Biphenyls (PCBs)
http://www.atsdr.cdc.gov/DT/pcb007.html

U.S. EPA Mercury Study Report to Congress
http://www.epa.gov/ttn/oarpg/t3/reports/volume5.pdf

5.6.7 Lake Superior AOCs

Saint Louis River
http://www.epa.gov/glnpo/aoc/stlouis.html

Torch Lake
http://www.epa.gov/glnpo/aoc/trchlke.html

Deer Lake
http://www.epa.gov/glnpo/aoc/drlake.html

Saint Marys River
http://www.cciw.ca/glimr/raps/connecting/st-marys/intro.html

Peninsula Harbor
http://www.cciw.ca/glimr/raps/superior/peninsula/intro.html

Jackfish Bay
http://www.cciw.ca/glimr/raps/superior/jackfish-bay/intro.html

Nipigon Bay
http://www.cciw.ca/glimr/raps/superior/nipigon-bay/intro.html

Thunder Bay
http://www.cciw.ca/glimr/raps/superior/thunder-bay/intro.html

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City of Grand Marais. 1999. *1998 Drinking Water Report.*

City of Silver Bay. 1999. *1998 Drinking Water Report.*

City of Two Harbors. 1999. *1998 Drinking Water Report.*

City of Washburn. 1999. *City of Washburn's Annual Quality Water Report "The Water We Drink"*.

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ADDENDUM 5-A
ATSDR AND HEALTH CANADA PROGRAM SUMMARIES

U.S. Agency for Toxic Substances and Disease Registry and Health Canada summaries of programs for the Great Lakes.

ATSDR:
The ATSDR's Great Lakes Human Health Effects Research Program (GLHHRP) serves as a model by which the requirements of the human health component of the Great Lakes Water Quality Agreement are being met. The goals of the GLHHRP are to 1) identify the populations at risk who may be exposed to chemical contaminants from the Great Lakes, and 2) prevent the potential adverse human health effects that research has demonstrated is associated with exposure. These goals represent the program's public health focus intended to protect the health of populations consuming contaminated Great Lakes fish. ATSDR has established an applied research strategy to achieve these goals based upon the traditional model of disease prevention (De Rosa and Johnson 1996, Johnson and others. 1998). These strategies are key requirements of the human health component of the Great Lakes Water Quality Agreement.

The GLWQA calls for the LaMPs "... to include a definition [description] of the threat to human health ... posed by Critical Pollutants, singly or in synergistic or additive combinations . . . ." (IJC 1994**.** The GLWQA also calls for the establishment of a surveillance and monitoring system, one of whose purposes it to identify emerging problems. For ATSDR, identification has involved identifying vulnerable populations and cohorts of populations who consume contaminated fish and have a potential for developing adverse human health effects (Anderson and others 1996; Courval and others 1996, 1999; Daly and others 1996; Fitzgerald and others 1996, 1999; Schantz and others 1996; Stewart and others 1999; Vena and others 1996; Waller and others 1996). The ATSDR cohort populations are part of a surveillance and monitoring system to identify emerging problems of long-term health effects associated with consumption of contaminants in fish.

Evaluation is another ATSDR strategy element used to determine causal linkages or conclusions regarding biologic plausibility. Early reports from the ATSDR's GLHHRP have demonstrated exposure associations between consumption of contaminants in Great Lakes fish and body burdens particularly for those with high fish consumption. The program has entered into a second evaluation phase in which associations are being established between body burdens of contaminants (e.g., in serum) and health effects observed in humans and animals.

As with the GLWQA, implementation is an integral part of ATSDR's strategy. Having helped to establish the pathway of exposure for at-risk populations, ATSDR's prevention strategy involves risk communication and health education to minimize the public's exposure to contaminants in fish (Tilden and others 1997). Health advisories for fish consumption are important means of communicating to the public the potential toxic effect from contaminants in Great Lakes fish. An ATSDR-funded research group has helped to develop uniform health advisory guidelines for fish consumption that is being utilized by the Great Lakes states. In addition to the funded research, ATSDR is presently preparing a report assessing health advisories for fish consumption within the Great Lakes states. This report will include an examination of some of the outreach approaches (e.g., pamphlets, posters, Internet) used by the Great Lakes states to disseminate health advisory information. As a further component of the prevention strategy, ATSDR has an ongoing program dealing with the effect of mixtures of chemicals found in the Great Lakes and other sites to determine synergistic or additive effects of these chemical mixtures (Hansen and others 1998). Within the next year, a toxicological profile will be published by ATSDR describing the state-of-the-science for chemical mixtures found in the Great Lakes and other hazardous waste sites.

As part of the impact assessment, ATSDR has established a process by which the GLHHRP projects are reviewed. Results of these research projects are customarily published to expand the public's awareness of potential adverse human health effects from consuming contaminated fish. ATSDR has also been participating in the Lakes Erie, Michigan, and Superior LaMP work groups, and has utilized this opportunity to 1) develop a human health section document that can be utilized as a prototype for all LaMPs, 2) inform the governmental and non-governmental agencies and the public about recent findings from the ATSDR funded research, and 3) develop an awareness about the current health-related issues in the Great Lakes basin that can assist in the direction of the GLHHRP.

This strategy and its component elements have represented major strides in helping to fulfill the requirements of the Great Lakes Water Quality Agreement by delineating the potential human health threat from contaminants in Great Lakes fish and by implementing actions that will protect human health. Having achieved these major steps, ATSDR is now making an effort to advance the science in relatively pristine areas such as mixtures effects from multiple chemicals found in the Great Lakes and other sites (Hansen and others. 1998), and the development of biomarkers of exposure. This step-by-step process will also be instrumental in building a data base of knowledge that can be utilized in dealing with other health- and environmental-related issues both nationally and internationally.

Health Canada's Great Lakes Health Effects Program.

Canadian federal government action to clean up and protect the Great Lakes ecosystem and fulfill Canada's international obligations under the Canada/USA *Great Lakes Water Quality Agreement* was formalized in 1989 with the launch of the Great Lakes Action Plan, a five year partnership between five departments, including Health Canada. The program was renewed in 1994 as the Great Lakes 2000 initiative, a six year partnership among seven federal departments. Federal actions to clean-up and protect the Great Lakes ecosystem are continuing under multi-departmental Great Lakes 20/20 Action Plan, toward fulfilling Canada's international obligations under the Canada-U.S. *Great Lakes Water Quality Agreement*.

The Great Lakes Health Effects Program (GLHEP) is Health Canada's contribution to the federal Great Lakes Program and the Canada-U.S. *Great Lakes Water Quality Agreement*. GLHEP's Mission is to protect the health of the Great Lakes basin population from the effects of exposure to environmental contaminants. Three major goals shape the Great Lakes Health Effects Program: To determine the nature, magnitude, and extent of effects on human health associated with exposure to contaminants (chemical, biological, radiological) from all sources of pollution in the Great Lakes basin.

- To manage the risks to human health related to pollution in the Great Lakes basin.
- To communicate and consult among agencies and the public and support informed decision making on health and environment issues.

Since 1989, GLHEP has conducted research on human exposure to environmental contaminants and on their effects on health. In addition, GLHEP has consulted with the public, professionals and industries throughout the Great Lakes basin, and has supported communities in addressing health and environment issues, including remedial actions within the 17 Canadian Areas of Concern (AOCs). GLHEP is a resource of information and expertise to a wide variety of audiences toward promoting and protecting human health from contaminants in the Great Lakes Basin.

GLHEP has worked in partnership with a range of partners to produce:
- research papers and technical documents detailing the latest state of knowledge on human health and the Great Lakes basin ecosystem;
- resource tools and materials for intermediaries such as educators and public health professionals, to assist them in providing health and environment advice and information to the public, and
- plain language audio/visual and written materials for the general public, to assist them in making informed choices about their health as it relates to the environment.

The GLHEP addresses human health from an ecological perspective, and has been involved with the Lake Superior, Lake Erie and Lake Ontario Lakewide Management Plans from their inception in the early 1990's. For the Lake Superior LaMP, GLHEP has participated on the LaMP Task Force, Work Group, and the Ecosystem Objectives Subcommittee, providing health expertise and advice, and ensuring that human health is considered at every step of the LaMP process. Further to this, GLHEP played an integral role in the recent development of the Human Health Subcommittee for the Lake Superior LaMP, providing co-chair function and working with a diverse range of health experts on this group.

For further information about Health Canada’s Great Lakes Health Effects Program, or to request our publications, contact:

Great Lakes Health Effects Program
Health Canada

Chapter 6

Status of Habitat in the Lake Superior Basin Progress Report

This chapter will be updated in 2004 as part of the new, consolidated ecosystem chapter for inclusion in LaMP 2006.

Cove Point beach of Lake Superior, Lake Superior, MN
Photograph by Dave Hansen, Minnesota Extension Service

Lake Superior Lakewide Management Plan
2004

Chapter 6 Contents

Chapter 6
Status of Habitat in the Lake Superior Basin

6.0 INTRODUCTION

The Habitat Committee is an historic and unique collaborative endeavor by Lake Superior resource managers to protect, maintain, and restore high-quality habitat sites in the Lake Superior basin and the ecological processes that sustain them. The Committee is comprised of technical personnel from federal, state, and provincial resource agencies and tribal authorities. This report highlights the actions taken to protect and restore habitat in the Lake Superior basin since the release of the LaMP 2002 document.

As directed by the Lake Superior Task Force and Work Group, four chapters of the LaMP 2000 document, Habitat, Aquatics, Terrestrial Wildlife, and Invasive Species, will be consolidated into one chapter. The resulting document will present information on the characteristics, status, and trends of living natural resources in the Lake Superior basin in a coordinated fashion. For basin outreach, the final document will be distributed to all biologists working in the Lake Superior Basin for their use and reference. The final document will be available for public review by Summer 2004.

6.1 LaMP 2002 TO 2004 ACCOMPLISHMENTS

6.1.1 Programmatic Accomplishment Highlights to Protect and Restore Lake Superior Habitat

The accomplishments described below reflect state, provincial, federal, tribal, and non-governmental efforts to achieve the goals of protection and restoration of habitat. This summary in no way encompasses all efforts in the basin, but rather is representative of significant accomplishments made since the release of the LaMP 2002 report. One of the tasks of the Habitat Committee is to compile and maintain a comprehensive list of actions and projects that identify, protect and restore habitat in the Lake Superior basin.

Lake Superior Decision Support System and Land Use Primer

Land use has evolved to be one of the most important issues in ecosystem management. The Lake Superior Land Use and Decision Support project consists of data and interpretive materials that address land use issues in the Lake Superior basin. These decision support materials were developed for use by local governments, regional planning agencies, individual resource management units, advocacy groups, educational and interpretive organizations, and individual citizens.

The primary goal of the project was to provide users with data and practical tools they can apply to local land and resource decisions in a context of basin-wide objectives for long-term sustainability and stewardship. Local units of governments were asked to assess the support tool using real land use issues. The tools are also of value to interpretive and educational institutions to foster public awareness of land use issues, since the real impact of forestry and development results from the cumulative effects of a large number of small land use decisions. The data are available in downloadable form or as interactive maps. The information is also available on CD and includes a Land Planning Primer developed in conjunction with the University of Minnesota Center for Rural Design. The Primer contains information on creating community-based land plans, developing landscape design strategies, and links to numerous data collection and planning resources. When integrated across time and space, these land use decisions have major impacts on the basin's resources. The Natural Resources Research Institute in Duluth, MN headed up this project in partnership with Minnesota DNR, the Habitat Committee of the LSBP, Minnesota Sea Grant, University of Minnesota Center for Rural Design, and ESRI, Inc.

More information is available at http://www.nrri.umn.edu/lsgis.

Central Lake Superior Watershed Partnership

The Central Lake Superior Watershed Partnership was established in Marquette County, Michigan, to provide watershed planning services, stream restoration, habitat protection, zoning improvement and other services related to ecosystem protection and restoration. The Partnership is facilitated by the Marquette County Conservation District and includes concerned citizens, area watershed councils, local governments and businesses.

The Partnership has produced two land use planning tools. The first is a document, "Your Upper Peninsula: A Guide to Planning for Tomorrow's Shorelines", which was distributed to every township and county in the Upper Peninsula. The second planning tool was a model riparian buffer ordinance designed to protect water quality and property values.

The Watershed Partnership has also completed some notable habitat restoration projects including many on the Salmon Trout River near Marquette. The Salmon Trout River is the only river on the south shore of Lake Superior that supports a naturally reproducing population of coaster brook trout. However, degradation has taken place over many years due to sedimentation from many different sources. Over the past three

A beautiful coaster brook trout from the Salmon Trout River

Photograph by Joe Wagner

years the Partnership, with help from the United States Fish and Wildlife Service, the Lake Superior Basin Trust, the Huron Mountain Club and the U.S. EPA's Great Lakes National Program Office, has completed projects including bridge installations, critical erosion control, bottomless arch culverts and sediment traps.

More information is available at http://www.superiorwatersheds.org/

A typical eroding culvert crossing in the Salmon Trout River Watershed
Photograph by Joe Wagner

One of several new, clear-span bridges that control erosion and allow fish migration
Photograph by Joe Wagner

The Status Of A Proposed National Marine Conservation Area In Lake Superior

The Lake Superior Binational Program (LSBP) promotes increased pollution prevention measures, special designations, and enhanced regulatory frameworks. In the early developmental stages of the program, one task of the Lake Superior Working Group was to identify opportunities for special designations which could apply to the lake basin --- to celebrate the unique and pristine character of the freshwater ecosystem and to maintain the integrity of this freshwater ecosystem. One such designation topped the list --- Parks Canada's national marine conservation area (NMCA) program.

National marine conservation areas (NMCA's) are established to protect and conserve representative marine areas for the benefit, education and enjoyment of the people of Canada and the world. They are managed for ecologically sustainable use to ensure lasting benefits of coastal communities. NMCA's also promote an understanding of the marine environment through research programs and monitoring initiatives and provide opportunities for education and public outreach. A Lake Superior NMCA could help achieve LSBP program objectives of enhanced awareness of a *Superior* environment, increased protection for critical habitats and endangered species while strengthening the existing management regime.

Between 1993 and 1995, scientific and technical data on the Lake Superior marine region was compiled and analyzed. By 1995, Parks Canada identified its preferred location for a feasibility study in the western end of the lake. A Memorandum of Understanding between the Federal and Provincial Governments was signed in 1997, launching a consultation process that would ultimately determine whether or not there was public support for the initiative.

Based on public consultations during a three-year feasibility study process, a regional stakeholder committee concluded in July 2000 that there was strong public support for the proposal. An independent review of this work completed the following year, recommended proceeding immediately with the establishment of an NMCA.

In June 2002, Parks Canada presented its vision for the development and operation of a Lake Superior NMCA in a series of north shore open houses. This vision was supported by 91% of the respondents, setting the stage for Federal-Provincial negotiations. On September 1, 2003, the Premier announced that Ontario would dedicate the lands and lakebed to create the NMCA.

The next step is the completion of a Federal- Provincial Agreement respecting the establishment of the NMCA. The Lake Superior NMCA would be the first legislated under the new *Canada National Marine Conservation Areas Act*, assented to in June 2002. It would also be the first NMCA established under Canada’s Action Plan for new national parks and marine conservation areas.

The Lake Superior NMCA is proposed to be over 10,000 km^2 and would represent the largest freshwater protected area in the world. Its establishment would be a remarkable achievement for Canada and Ontario, and would signal a firm commitment to protect and conserve freshwater ecosystems for the enduring benefit of future generations.

Interactive Kiosks Available to Public

Public education is an important principle recognized by the Habitat Committee to help achieve its goals to protect and restore fish and wildlife habitat in the Lake Superior basin. Pictures, maps and information on the special places and habitat of Lake Superior teach people the value of protecting the resource for future generations and in maintaining a sustainable economy. The Habitat Committee has been working with local governments around the basin to make interactive computer kiosks available to the public. The kiosks consist of a touchscreen computer using Site Explorer© software that allows people to access a variety of information on Lake Superior’s wildlife, special places, and significant habitat. An important source of this information comes from another of the Habitat Committee’s long-term projects, the Lake Superior GIS database and Decision Support System. There were four kiosks operating in 2003 in the following locations: Great Lakes Aquarium, Duluth, MN; Great Lakes Visitor Center, Ashland, WI; Thunder Bay Visitor Centre, Thunder Bay, ON; and Ottawa National Forest Visitor Center, Watersmeet, MI. A fifth Kiosk was also presented to the City of Sault Ste. Marie, Ontario by the Habitat Committee in September 2003.

Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem (COA)

The Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem (COA) is a commitment by the governments of Canada and Ontario to cooperate and coordinate their efforts to restore, protect and conserve the Great Lakes Basin ecosystem. It builds on the actions taken through previous agreements, and focuses priorities for future actions.

The COA recognizes the need to continue to tackle the most pressing issues - such as the clean up of the five remaining Canadian Areas of Concern on Lake Superior, increased binational cooperation on restoration, and the reduction of harmful pollutants. The Agreement can also be amended to respond to emerging issues. The COA recognizes the need for governments to help those at the local level tackle many pressing problems. In this way, community involvement is mobilized and the Lake Superior basin ecosystem benefits through actions targeted to meet specific area needs. This agreement has provided funds to complete a number of habitat related projects in the basin including habitat inventory and assessment projects and the stream rehabilitation effort described below.

Blind and Wildgoose Creek Rehabilitation in Thunder Bay, ON

Blind and Wildgoose Creeks are small tributaries of Thunder Bay with rainbow trout and potential coaster brook trout populations. Habitat in the lower reaches of both creeks has been degraded through flooding and improper water crossings. A rehabilitation plan has been prepared for both streams. The goal of increasing stream productivity in the lower reaches and removing impediments to fish migration is the focus of this project scheduled for completion in 2006. The plan also calls for one year of post rehabilitation monitoring on each of the tributaries.

In 2002 and 2003, perched culverts on Wildgoose Creek were replaced and stream sections were remediated. These modifications enhanced upstream fish passage and stabilized the lower reaches of Wildgoose Creek. Surveys of Blind Creek were also undertaken in the lower reaches where problematic sections had been identified. Engineering studies have now been completed and construction is scheduled for 2004.

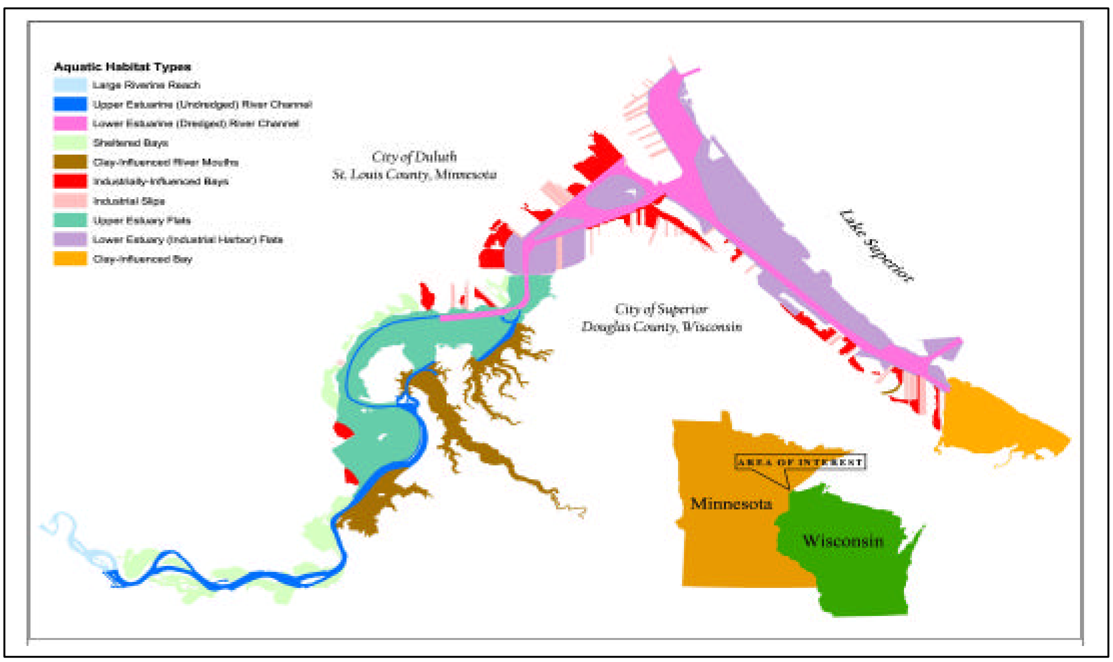
St. Louis River Citizens Action Committee (CAC).

The St. Louis River Area of Concern (AOC) includes 39 miles of the St. Louis River below Cloquet, MN, the river estuary, Duluth-Superior Harbor, the lower Nemadji River and the near-shore waters of Lake Superior. Some of the impairments in the AOC not only include the physical loss and degradation of habitat but many years of impairment from industrial discharges, untreated wastewater, non-point source pollution and other disposal practices. Many of these pollution-based impairments are being addressed through the implementation of a Remedial Action Plan for this AOC.

The St. Louis River CAC worked with local, state and federal agencies to develop an overarching Habitat Plan that will guide protection and restoration of habitat in the AOC for many years to come. The Habitat Committee of the CAC included the following in the plan:

1. A detailed and comprehensive synthesis of existing information.
2. An estuary-wide guide for resource management and conservation that would lead to adequate representation, function, and protection of ecological systems in the St. Louis River, so as to sustain biological productivity, native biodiversity, and ecological integrity.
3. A list of conservation and management objectives that reflects a consensus of the Habitat Committee members.
4. A suite of specific, obtainable, prioritized conservation and management actions that address specific threats.

More information is available at http://www.stlouisriver.org/



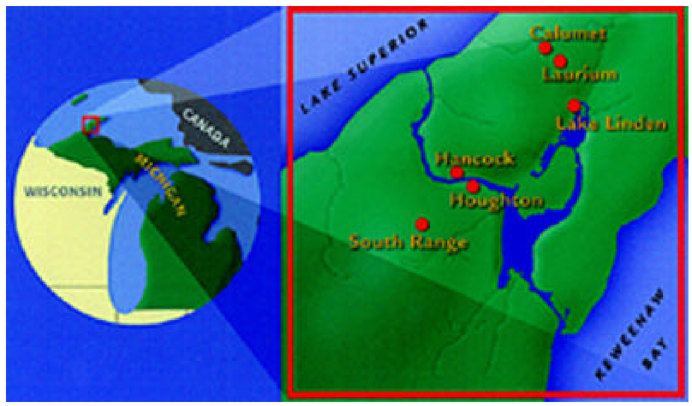
Map produced for St. Louis River Habitat Plan

Torch Lake River Superfund Site
Cleanup Project Creates New Plant and Wildlife Areas

U.S. EPA's cleanup and restoration efforts on the Torch Lake Superfund site made excellent progress in 2003. Refuse from copper production activities was covered by soil caps and erosion protection was installed in the cleanup areas. Also in 2003, U.S. EPA enlisted assistance from science teachers and students from four area high schools to help monitor plants and wildlife as the cleanup areas recover.

Background

Torch Lake is located on the Keweenaw Peninsula which roughly divides Lake Superior's southern shore into its eastern and western halves. The problem encountered in this area is widely scattered deposits of copper mining waste materials accumulated over more than 100 years of mining, milling, smelting, and recovery activities. These wastes occur both in upland areas and in the lake and occur in four forms: poor rock piles, slag and slag enriched sediments, stamp sands, and abandoned mine slurry settling ponds. The associated contaminants include copper, mercury, arsenic, lead, chromium, and other heavy metals.



Source: U.S. EPA

Restoration Activities

U.S. EPA began cleaning up the area in 1988 when the Agency removed dozens of buried and sunken barrels containing toxic waste. Torch Lake was placed on the Superfund list in the 1990's and clean up activities began focusing on removing copper wastes and restoring habitat. In 1999, U.S. EPA began work on cleaning and restoring 800 acres of contaminated sands and slag areas. This work was completed in 2002. Work was begun on additional sites in 2003. Cleanup activities at all of these sites includes:

- Leveling and grading the areas to be covered;
- Constructing waterways and water diversions;
- Creating access roads;
- Covering the contaminated sand with 6 inches of clean sandy soil and seeding;
- Putting large rocks or rip rap on shorelines for erosion protection; and
- Installing chain link fences for site security where necessary.

These cleanup activities have created new terrestrial and aquatic habitat. U.S. EPA formed a team of scientists to study the effect the cleanup was having. The scientists found plenty of life on the restored areas. Small mammals such as chipmunks, voles, and mice were live-trapped on the cleanup sections. Anywhere from 11 to 19 different bird species were also observed. Only six or seven species were planted on top of the soil coverings, but the survey identifies 76 different plant species growing there. This indicated that the cleanup process is successful, as barren, lifeless sand is turned into thriving habitat.

6.1.2 Summary of Local Management Activities to Protect and Restore Lake Superior Habitat

In addition to the project highlights listed above, a number of other local and regional activities to protect and restore habitat were completed in the past two years.

Habitat Restoration and Rehabilitation

This category includes activities that improve habitat features or processes and benefit native plant, animal communities or species as the result of direct management actions.

- The Keweenaw Bay Indian Community (KBIC) located on Lake Superior's Keweenaw Bay in Michigan's Upper Peninsula completed construction of a large arched culvert that allows fish passage into Zeba Creek's 3.2 sq. mile upper watershed area. Installation of the eight-foot tall aluminum culvert was a product of collaboration by many partners and will allow the Tribe's stocked fish as well as indigenous fish species access to Lake Superior, greatly enhancing the fishery in Keweenaw Bay.

- A power dam was removed from the Iron River, about 1.5 miles above where it enters Lake Superior. What had been a warm water impoundment as large as 144 acres was restored to 1.2 miles of trout stream. The original hydropower dam was constructed in 1923 and destroyed by a flood in 1946. A replacement dam 56 feet high was built slightly downstream in 1947, and was operated by Northern States Power (NSP) until 1985, when it was again damaged by flood. In 2001, the remaining barrier was removed from the sandstone outcrop known as Orienta Falls, which old newspaper articles called the most scenic site in Bayfield County. At Orienta Falls, water drops 15 to 20 feet over a distance of 200 feet. A low-head barrier dam was also constructed to keep sea lamprey out of the 56 miles of trout streams in the Iron River watershed. The river is returning to a more natural state and lake-run salmonids are reproducing once again

- The U.S. Forest Service (Hiawatha, Ottawa, Chequamegon/Nicolet and Superior National Forests) accomplishments reported since the LaMP 2002 include 20.3 miles of stream restoration, 20 acres of riparian habitat improvement, 466 acres of inland lake restoration, 1440 acres of moose habitat restoration, 350 acres of fire-dependent ecosystem restoration, and 79 acres of wetlands restored. Sediment control efforts included replacement of 29 culverts, construction of four trail and one road bridge, and stabilization of six cut/fill sites resulting in a total estimated 225 tons of sediment reduced per year.

- The U.S. Fish and Wildlife Service planted 10 acres of trees as a riparian forest restoration project within the Whittlesey Creek National Wildlife Refuge. They also initiated a purple loosestrife control project on the refuge through biological control and mapped habitat types within the refuge boundary.

- In May 2001, the U.S. Fish & Wildlife Service designated critical habitat for the Great Lakes piping plover, a federally endangered species. Critical habitat receives protection under section 7 of the Endangered Species Act through the prohibition against destruction or adverse modification with regard to actions carried out, funded, or authorized by Federal agencies. Critical habitat was designated throughout all of the Great Lakes basins. Within the Lake Superior basin five critical habitat "units" were designated totaling 73 miles (120 km) of shoreline in Michigan, Wisconsin, and Minnesota. Once found breeding in many places along Lake Superior, piping plovers currently nest in only two shoreline areas. Protection of critical habitat will facilitate recovery and return of piping plovers to many historical breeding sites on Lake Superior and throughout the Great Lakes.

Watershed Management and Forest Stewardship Projects

- A project is being implemented in Wisconsin to develop best land management practice guidelines for the Wisconsin portion of the Lake Superior basin in order to reduce non-point pollution and stream damage. The project was funded by the Great Lakes Protection Fund and is being implemented by the Ashland, Bayfield, Douglas and Iron Counties' Land and Water Conservation Department with assistance from the Wisconsin DNR.

- The U.S. Forest Service submitted two draft National Forest Plans and Environmental Impact Statements and two Notices of Intent to prepare Forest Plans. These are expected to be final by the LaMP 2006 report.

Special Designations and Acquisition Projects to Protect Habitat

- A grant was given to the St. Louis County Soil and Water Conservation District to acquire an easement on Miller Creek in Duluth, MN.

- The Chocolay Township in Michigan has passed a milestone dune protection ordinance defining building setbacks, limiting tree removal and prohibiting such once common practices as bulldozing the dunes to provide better views of Lake Superior.

- In June 2002, Parks Canada presented its vision for the development and operation of a Lake Superior National Marine Conservation Area (NMCA) in a series of north shore open houses. This vision was supported by 91% of the respondents, setting the stage for Federal-Provincial negotiations. On September 1, 2003, the Ontario announced that it would dedicate the lands and lakebed to create the NMCA.

Monitoring, Assessment, and Inventory Projects

- The Wisconsin DNR is supporting the Lake Superior Alliance in a project called the Bayfield County Shoreline Protection Campaign. The project includes a survey of shoreline communities in Bayfield County, information on Lake Superior's unique shoreland ecosystems, informational meetings, and the development of a working group to move proposed zoning and planning provisions to the appropriate government units.

Education and Public Involvement

- The Wisconsin DNR is assisting the Lake Superior Research Institute (LSRI) with a project based on the University of Connecticut Extension's Nonpoint Education for Municipal Officials (NEMO). The goal of the project is to provide community planners with information about the connection between land use, non-point sources of pollution, and impacts on water quality.

- A project to provide educational programming and materials to support a Lake Superior watershed health initiative is being implemented through the Lake Superior Basin Education Partnership established between the Wisconsin DNR, LSRI and the University of Wisconsin Extension (UWEX). The project will result in a GIS layer of brook trout spawning habitat and will provide educational programming on watershed factors affecting this habitat.

- UWEX, Wisconsin DNR, and the Lake Superior Binational Forum sponsored the Lake Superior Water and Land Symposium on the Bad River Reservation in September 2003. The symposium delivered information on planning for habitat protection in the Lake Superior basin to more than 300 government officials, natural resource people and watershed groups.

- In Marquette, MI, the Central Lake Superior Watershed Partnership hosted a conference titled "Partnering with Upper Peninsula Land Conservancies to Achieve Your Conservation and Community Goals" in November 2002.

6.2 CHALLENGES FOR 2004 TO 2006

The long-term goal of the Habitat Committee is to support a variety of activities that identify, protect, and restore high-quality habitat sites in the Lake Superior basin and the ecosystem processes that sustain them. The Committee has identified a number of challenges to meeting this goal.

- Provide ongoing support and maintenance of the geographic database and projects associated with the Lake Superior Decision Support System. This information is essential to the effective implementation of the LaMP as it provides natural resource information to decision makers.

- Fill information gaps on the status and trends of habitat conditions in the Lake Superior basin and developing management recommendations to protect and restore important habitat sites.

- Encourage active participation on the Habitat Committee by members of agencies and organizations that are doing habitat work in the basin.

- Educate the public on important habitat and ecological resources in the Lake Superior basin by expanding the use of interactive information kiosks.

6.3 NEXT STEPS FOR 2004 TO 2006

During the next two years, the committee plans to complete the following items:

- Solicit and enter information to update information on projects listed in the LaMP 2000 and include new projects such as those highlighted in this report.

- Identify personnel to maintain, update and expand the Lake Superior GIS project data and databases and respond to information requests.

- Maintain the current kiosk network and update information in the databases.

- Expand membership and participation in the Habitat Committee with representation from all agencies and organizations that are doing habitat work in the Lake Superior basin.

- Maintain and update the Habitat Committee's web site.

- Consolidate the Ecosystem Chapter of LaMP 2000.

Members of the Habitat Committee

Co-chairs:	Marilee Chase, Ontario Ministry of Natural Resources Ann McCammon-Soltis, Great Lakes Indian Fish and Wildlife Commission
Members:	Mike Ripley, Chippewa Ottawa Resource Authority Marc Slis, Keweenaw Bay Indian Community Joan Elias, National Park Service Robert Morriseau, Fort William First Nation Brigitte Collins, Canadian Wildlife Service

Chapter 6

Status of Habitat in the Lake Superior Basin

Island near Rossport, ON
Photograph by: Patrick T. Collins, MN DNR

Lake Superior Lakewide Management Plan
2000

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EXECUTIVE SUMMARY

The Habitat chapter of the Lake Superior LaMP 2000 consists of four main elements. Section 6.1 summarizes the status of habitat conditions in Lake Superior and its watershed. Section 6.2 outlines both a strategic and operational approach to addressing known issues and opportunities for habitat protection and restoration. Section 6.3 identifies actions underway or already completed that help restore/protect habitat in the basin. The fourth element is a map of known sites of important habitat in the watershed.

Section 6.1 of the habitat chapter represents results to date of efforts to summarize the status and trends of habitat features and ecological processes in the Lake Superior basin. While the summary is not yet complete, and broad, regional consensus has yet to be developed for the results and conclusions, some preliminary findings are emerging.

Habitat in the Lake Superior watershed supports high quality, diverse plant and animal communities. The habitat in the watershed remains in good shape despite extensive historical modifications and current stresses. The Lake Superior landscape has been modified by historic and current forest use as well as development of shorelines and forested areas. Chemical changes in water and sediments have, in some cases resulted in degraded habitat conditions for some species and communities. There have been substantial changes in the species composition of some natural communities through the introduction of non native species. Land use changes and decisions have both local and regional (sometimes lakewide) effects. Changing a mixed conifer forest to an early successional hardwood forest on highly erodible clay soils for example, can result in faster runoff of stormwater, increased streambank erosion, and higher rates of sedimentation in important fish spawning areas downstream.

Section 6.2 of the habitat chapter identifies a number of essential principles and strategies that support the protection and restoration of habitat in the Lake Superior basin. These strategies are presented as a starting point in the hope of developing a broad consensus of priorities among resource managers around the watershed. The goals for habitat that the Lake Superior Binational Program has endorsed are: 1) to protect and maintain existing high-quality habitat sites in the Lake Superior basin and the ecosystem processes that sustain them, and 2) to restore degraded plant and animal habitat in the Lake Superior basin.

Four high-priority strategies are identified, representing substantial regional consensus for habitat needs. These strategies are (1) implementation of habitat components of the Great Lakes Fishery Commission's rehabilitation plans for lake trout, lake sturgeon, walleye, and coaster brook trout; (2) complete comprehensive, systematic Natural Heritage Inventory/biological surveys in the watershed to identify remaining high-quality natural communities; (3) develop site conservation plans for known sites of important habitat and implement strategies to maintain habitat features;

and (4) implement habitat restoration/protection projects at sites meeting one or more of the committee's "ecological criteria for the identification of important habitat in the Lake Superior basin."

Section 6.2 also identifies actions and projects that entities working to improve habitat in the basin have either committed to or proposed. Where an agency is identified in association with a project, a level of commitment is indicated. "Commitment" means that funding has been secured for the project and that it has either just begun or will begin in the next year. Commitments made in this section will be tracked for reporting in the LaMP 2002. "Exploratory" indicates that the agency has proposed the project and is in the process of securing funding or other key support before beginning. These projects will also be tracked in the hope that the required support will be generated.

Finally, Section 6.2 sets out priorities for Habitat Committee work during the next two years. An important role for the Habitat Committee will be to facilitate discussion about habitat status, trends, stresses and sources of stress to the Lake Superior basin in order to achieve consensus for coordinated action. Section 6.1 will serve as a starting point for these discussions. Another role for the Committee will be to communicate the broad range of the habitat protection and restoration efforts under way throughout the basin. The World Wide Web will provide an important tool to help the Committee achieve this end.

There have been, and continue to be many projects to identify, protect and restore habitat in the Lake Superior watershed. More than 120 projects have been identified that support the Lake Superior Binational Program's goals and principles of habitat protection and restoration. These projects include efforts that can be categorized as 1) Habitat Restoration and Rehabilitation, 2) Special Designations and Acquisition, 3)Watershed Management and Forest Stewardship, 4) Monitoring, Assessment and Inventory, or 5) Education and Public Involvement.

More than 70 project summaries have been developed with the assistance of the people working on the projects. This compilation of project summaries was developed to document the work being done throughout the watershed that furthers the goals and strategies identified in the previous chapter of this LaMP. Where information was available, project summaries were developed in Section 6.3. Following the project summaries is a list of projects for which summary information is still needed. This report provides an encouraging picture of the many local and basin-wide efforts that have been undertaken. It is not a complete listing of all such projects. Development of this information will continue and can serve to provide a reference to natural resource managers and the Lake Superior community.

Developing and maintaining an inventory of important habitat sites in the basin has been a key charge of the Lake Superior Binational Program since its inception. The map "Important Habitat in the Lake Superior basin" included in this chapter represents a substantial improvement in the quality and quantity of geographic data available at the scale of the watershed since the original important habitat map was published in 1996. Revisions and improvements in habitat site information databases have also been made that substantially improve our inventory and our understanding of the range of sites and areas known to be important habitat. More than 300 important habitat areas and sites are now part of the inventory database.

Actions

Figure 6-1 summarizes actions and projects to identify, protect and restore habitat in the Lake Superior watershed. Figure 6-1 also delineates which projects are funded and those that need funding commitments. Finally, the action summary indicates the agencies and groups responsible for funding and/or managing these projects. These actions are described in further detail in Section 6.2.

Figure 6-1 Action Summary

Project	Lead Agency/ Funding Source	Funded	Needs Funding
Marsh reclamation - Thunder Bay	OMNR	X	
Cypress River Rehabilitation	OMNR	X	
Habitat requirements of coaster brook trout in Lake Superior - Nipigon Bay	OMNR		X
Biological Survey of North Shore Highlands Subsection	MN DNR	X	
Lake Superior Habitat Coordination	MN DNR	X	
Classify physical habitat in nearshore waters of Lake Superior in Michigan	MI DNR		X
Aquatic community survey in Michigan tributaries	MI DNR	X	
Develop communications package to highlight results of habitat projects.	LSHC		X
Develop regional consensus amongst resource managers on status of habitat and basin wide strategies using the LaMP2000 as the basis for agreement	LSHC		X
Maintain and continue to develop and distribute basin wide GIS data and decision support projects through the existing Lake Superior Decision Support project.	LSHC		X
Continue to develop and expand the Committee web site.	LSHC		X
The Central Lake Superior Watershed Project	CLSWP	X	
City of Marquette Riparian Habitat Protection	CLSWP		X
Salmon Trout River Watershed Project	CLSWP		X
Purple loosestrife and exotic plant control	GLIFWC	X	
Piping plover critical habitat designation	USFWS	X	
Whittlesey Creek restoration	USFWS	X	
Iron River Sea Lamprey Barrier	USFWS		X
Coordination of Superfund remediation and restoration with LaMP and RAP partners	U.S. EPA	X	
Complete remediation at Torch Lake and St. Louis River Superfund sites by 2005	U.S. EPA	X	
Work with LaMP/RAP partners to provide outreach and education on Brownfields redevelopment to local land use planners and decision makers	U.S. EPA	X	
Complete GIS maps of U.S. shoreline that include important habitat data by 2001	U.S. EPA	X	

6.0 ABOUT THIS CHAPTER

The Habitat chapter of the Lake Superior LaMP 2000 consists of four main elements. Section 6.1 summarizes the status of habitat conditions in Lake Superior and its watershed. Section 6.2 outlines both a strategic and operational approach to addressing known issues and opportunities for habitat protection and restoration. Section 6.3 identifies actions underway or already completed that help restore/protect habitat in the basin. The fourth element is a map of known sites of important habitat in the watershed.

6.1 STATUS OF HABITAT IN THE LAKE SUPERIOR BASIN

Section 6.1 is a discussion of the major habitat components in the Lake Superior basin, including the terrestrial and aquatic ecosystems.

Section 6.1 has the following components:

1. A description of the physical attributes and biological communities that make up the basin
2. A discussion of rare and declining species and communities and other significant plants and animals
3. Discussion of the stresses on the habitat.

It is based on a synthesis of data and reports from a variety of sources from the agencies around Lake Superior. These include “gray literature” from government sources, scientific papers, and personal communications from resources managers. Maps and tables are incorporated wherever possible.

6.1.1 The Lake Superior Basin

6.1.1.1 Geology and Glacial History

Most of the Lake Superior Basin is underlain by the Precambrian Canadian Shield (Figure 6-2), consisting of ancient sedimentary, igneous and metamorphic rocks. Volcanic rocks, ranging in age from ca. 2.9 to 2.7 billion years ago, along with related sedimentary rocks, form "greenstone" belts.

The Midcontinent Rift extends from southwest of Lake Superior, under the lake, and south through Michigan. During a period of approximately 20 million years (ca. 1110 to 1090 million years ago), an estimated 2 million km^3 of volcanic rocks, dominantly flood basalts, were erupted. Coarse, sedimentary rocks were deposited during hiatuses in eruption activity. Associated, intrusive igneous rocks predominate in northeastern Minnesota, as well as around Lake Nipigon, and extend north of Lake Superior. Rocks of the Midcontinental Rift are only exposed around Lake Superior. Elsewhere, they are overlain by younger sedimentary rocks.

Sedimentary rocks of the Cambrian (570 to 500 million years ago) and Ordovician (500 to 440 million years ago) periods are restricted to the southeastern portion of the Lake Superior Basin, near Sault Ste. Marie. They are situated in an area of subsidence in which sandstones, limestones and other sedimentary rocks accumulated during Paleozoic time (Figure 6-2).

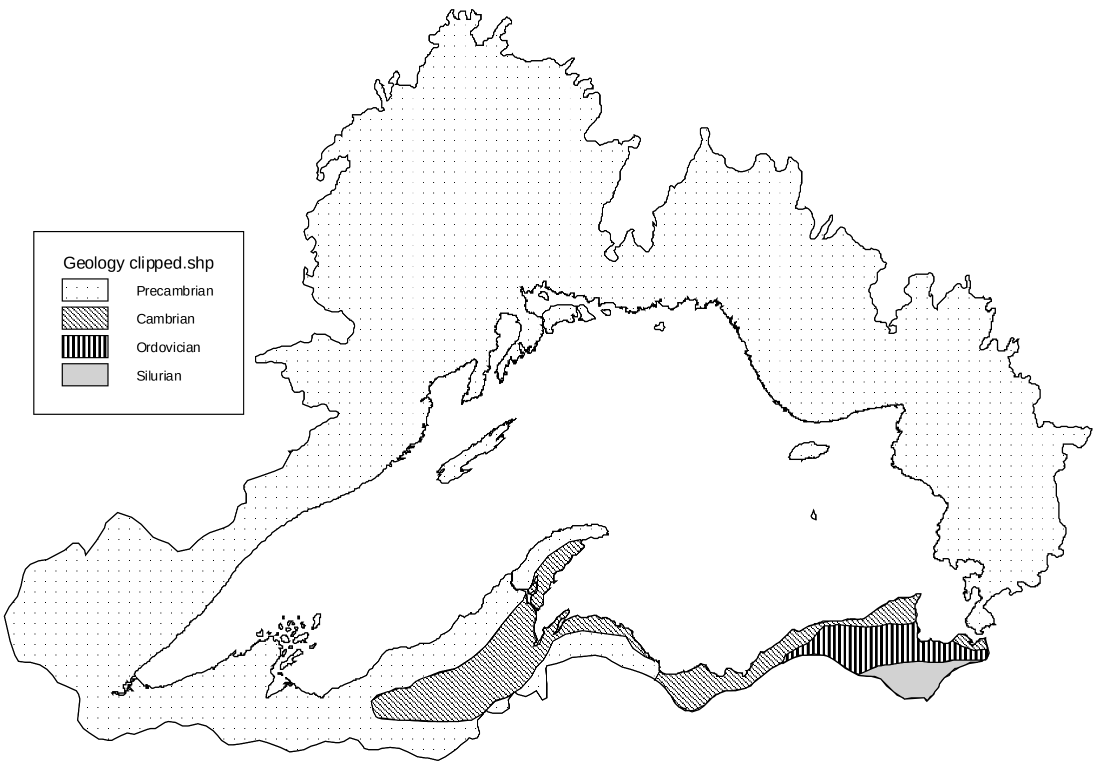


Figure 6-2. Generalized Geology of the Lake Superior Area (Government of Canada and U.S. EPA 1995)

Glacial History

Twenty thousand years ago, the Lake Superior Basin was covered by the Laurentide ice sheet. The most recent stage of glaciation, the Wisconsin, began approximately 115 thousand years ago and ended 10 thousand years ago.

Erosion caused by advancing ice produced widespread till deposits of varying thickness, whose composition reflects the eroded source:

- Sandy tills, derived from the erosion of crystalline Precambrian rocks
- Silty tills, derived from the erosion of Paleozoic carbonate rocks; and
- Clayey tills, derived from the incorporation of proglacial, glaciolacustrine sediments.

Till is less than one meter thick over much of the rocky uplands bordering Lake Superior. However, in bedrock valleys or in areas south of Lake Superior, glacial drift thickness may average 30 to 60 meters and may exceed 200 meters.

Although the front of the Laurentide ice sheet began its final recession 15 thousand years ago, ice remained in the Lake Superior basin until about 9.5 thousand years ago. The ice margin was very lobate in the Great Lakes region in response to topographic controls and ponded water near the ice front. The retreat of ice about 11 thousand years ago was accompanied by the development of proglacial, ice-contact lakes. Lake Duluth and Lake Ontanagan developed on the southwestern and southern flanks of the Superior lobe, respectively. Water from Lake Duluth drained southward via the Brule-St. Croix valley into the Mississippi River valley. Glaciolacustrine sediments (gravel, sand, silt and clay) were deposited in these fluctuating lake basins as the ice sheet retreated northward. Flowing meltwater produced outwash deposits of stratified sand and gravel.

The Marquette Readvance of the Superior ice lobe 10 thousand years ago filled the Lake Superior basin with ice and extended down to the Grand Marais moraines in northern Michigan. Following the retreat of Marquette ice, glacial Lake Minong developed and eastern outlets for glacial Lake Agassiz developed through Lake Nipigon. The resultant flooding may have triggered the erosion of the drift barrier at the eastern end of the Superior basin, leading to rapid lowering of water levels, culminating in the lowest, Houghton phase ca. 7.5 thousand years ago. Following the rebound of the North Bay outlet, water from the Nipissing Great Lakes flooded into the Superior basin, giving rise to the Nipissing maximum level. Many of the resultant, raised shorelines now preserved around Lake Superior are related to a main, beach-forming event approximately 4.6 thousand years ago. Lake levels subsequently fell to lower levels, such as the Algoma, Sault and Sub-Sault. The basin was isolated when uplift of the St. Mary's River sill ca. 2.2 thousand years ago isolated the Superior basin, resulting in the Sault and later, Sub-Sault levels that are only represented in the Superior basin. Modern-day levels of Lake Superior, ca.183 meters above sea level, were substantially achieved approximately 2 thousand years ago.

Isostatic rebound of ice-depressed land around the basin during progressive deglaciation has led to submergence and emergence on the southern and northern shores of Lake Superior, respectively. Rates of submergence at Duluth, Minnesota have been estimated at 0.21 meters per century while emergence rates of approximately 0.27 meters per century have been estimated in the Michipicoten area of Ontario.

Table 6-1 Post-glacial lake phase names for the Lake Superior Basin, with approximate ages (from Geddes and others 1987)

YEARS BEFORE PRESENT	LAKE PHASE	ELEVATION (At Marathon, Ontario; In Metres Above Sea Level)
0	(present Lake Superior level)	183
1000	Sub-Sault	190
2000	Sault	197
3000	Algoma	205
5000	Nipissing	220
6000		
7000	Houghton	246
8000	Post-Minong IV (Dorion) III II I	260 270 280 292
9000 9500	Minong III II I	308 315 325

6.1.1.2 Climate

Lake Superior has a strong effect on the climate of Wisconsin, Michigan and eastern Ontario, but less on Minnesota and the northern part of the basin (Albert 1995). While mean annual temperatures increase steadily from north to south (Figure 6-3), the lake has a strong effect on climate within a few km of the shore. Shorelines experience cooler summers and milder winters than sites a few kilometers inland. Winter storms tend to be more intense near the lake, but the lake increases stability of the air masses and reduces the intensity of spring and summer storms (Albert 1995).

The wettest areas are immediately east of the lake, north of Sault Ste. Marie, Ontario, and parts of Wisconsin and Michigan where there is a strong lake influence (Figure 6-4). These areas also have the greatest snow accumulation. Portions of the Michigan Upper Peninsula average 875 cm of snow while Duluth, outside the greatest lake influence, receives only 138 cm (MPCA 1997).

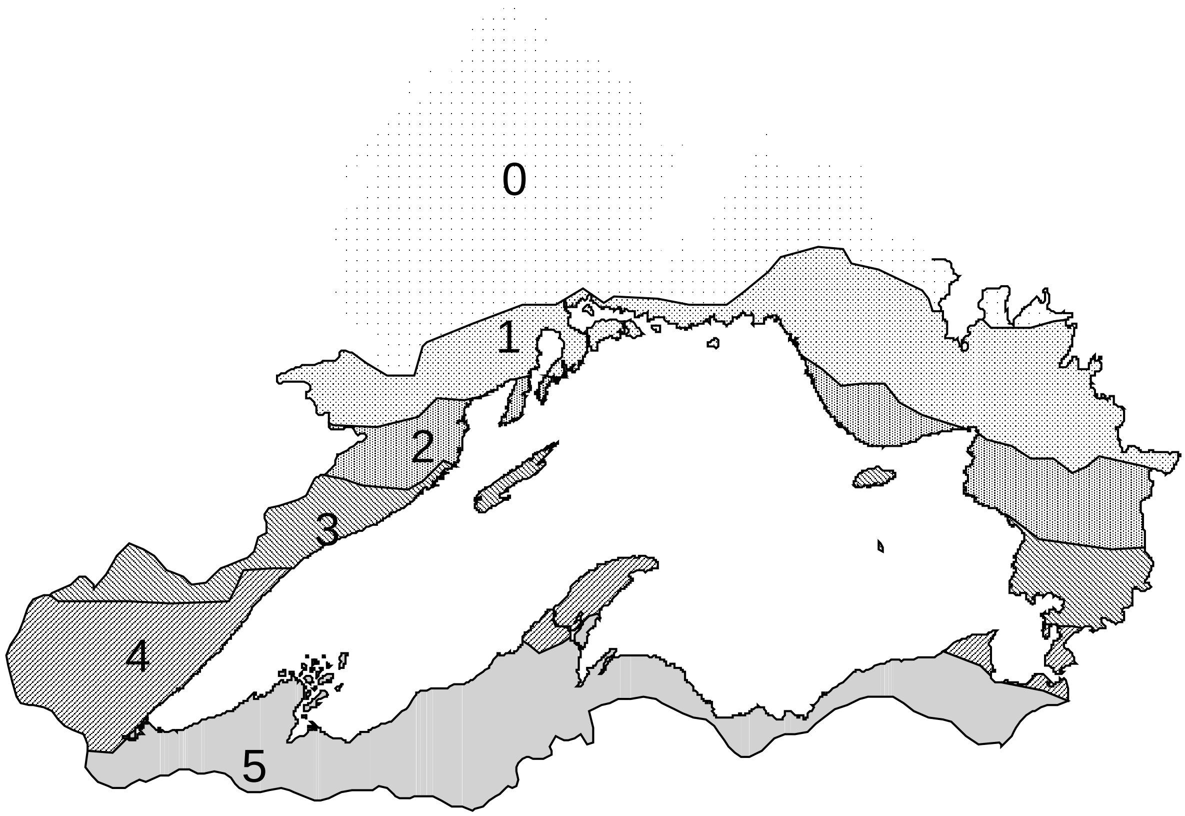


Figure 6-3. Mean annual temperatures calculated from monthly values (Lake Superior Decision Support Systems data) The numbers are mean temperatures in degrees Celsius.

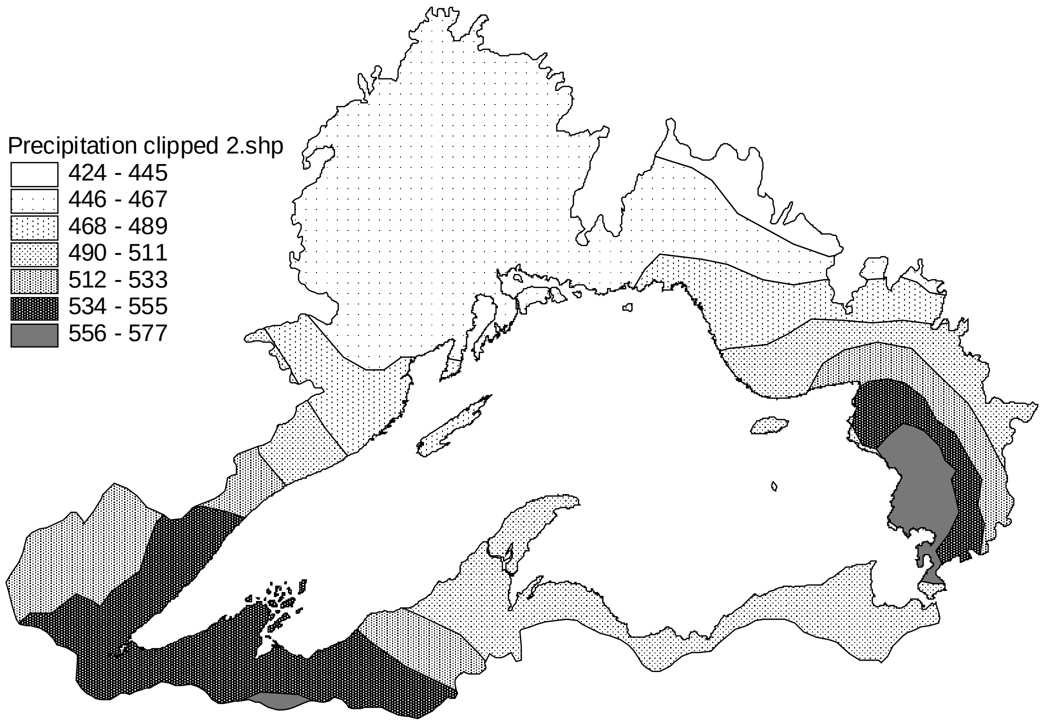


Figure 6-4. Growing season precipitation (Lake Superior Decision Support Systems data)

6.1.1.3 Human Population

The human population of the Lake Superior is estimated at 607,121 people (Environment Canada and U.S. EPA 1995). Most of the basin is sparsely populated. Most of Ontario and the Minnesota north shore has less than 2 people / km^2. Population density is greater on the on the south shore of the lake. Centers of population are at Thunder Bay, Duluth/Superior and Sault Ste. Marie (Figure 6-5). Note that census areas partly overlap the basin and reflect population statistics from outside the basin.

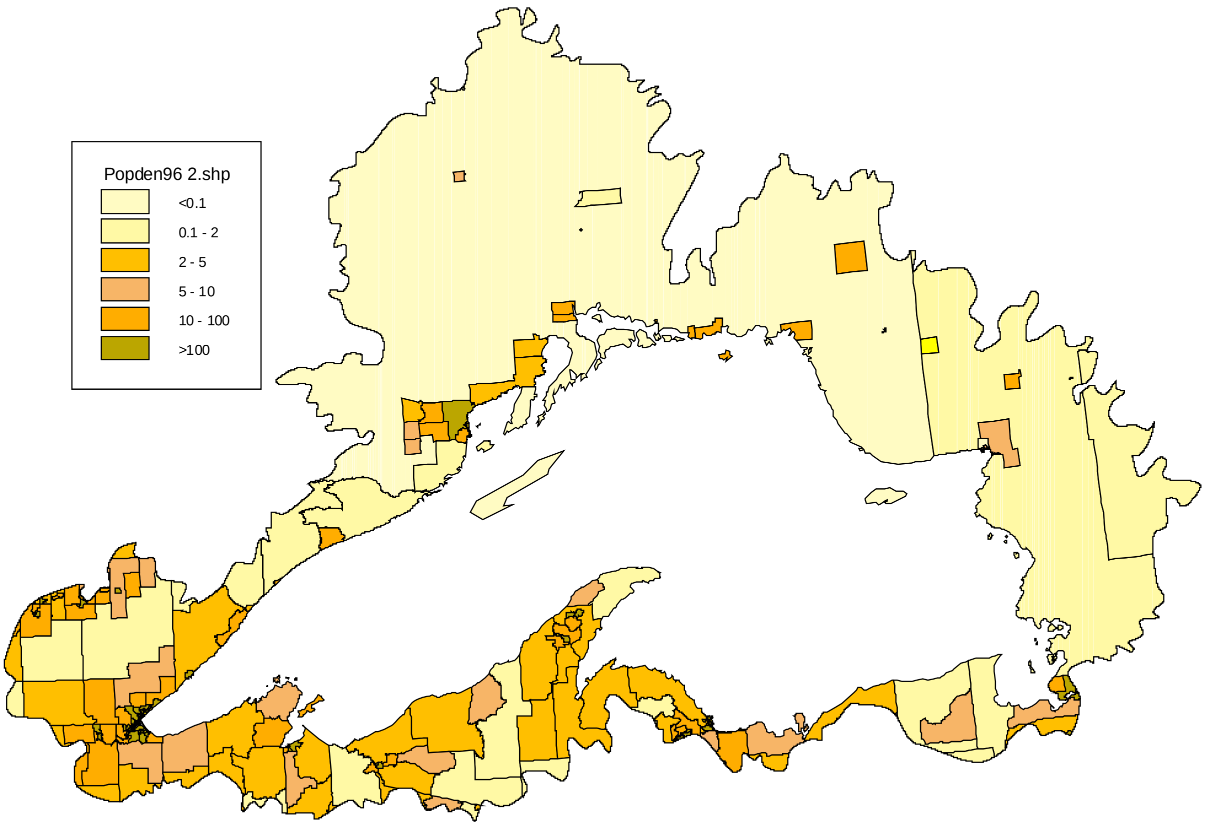


Figure 6-5. Population density of the Lake Superior Basin in 1996 (people/km^2) (Lake Superior Decision Support Systems Data, based on U.S. and Canadian census data)

Most of the basin experienced a small increase in population (0 – 5 percent) between 1991 and 1996. The greatest population growth was on the Minnesota north shore and adjacent Ontario, the Keweenaw Peninsula and the area west of Sault Ste. Marie Michigan (Figure 6-6). The population density in most of these areas remains low, however. Other areas with increasing populations include the Duluth/Superior area and the Bayfield Peninsula.

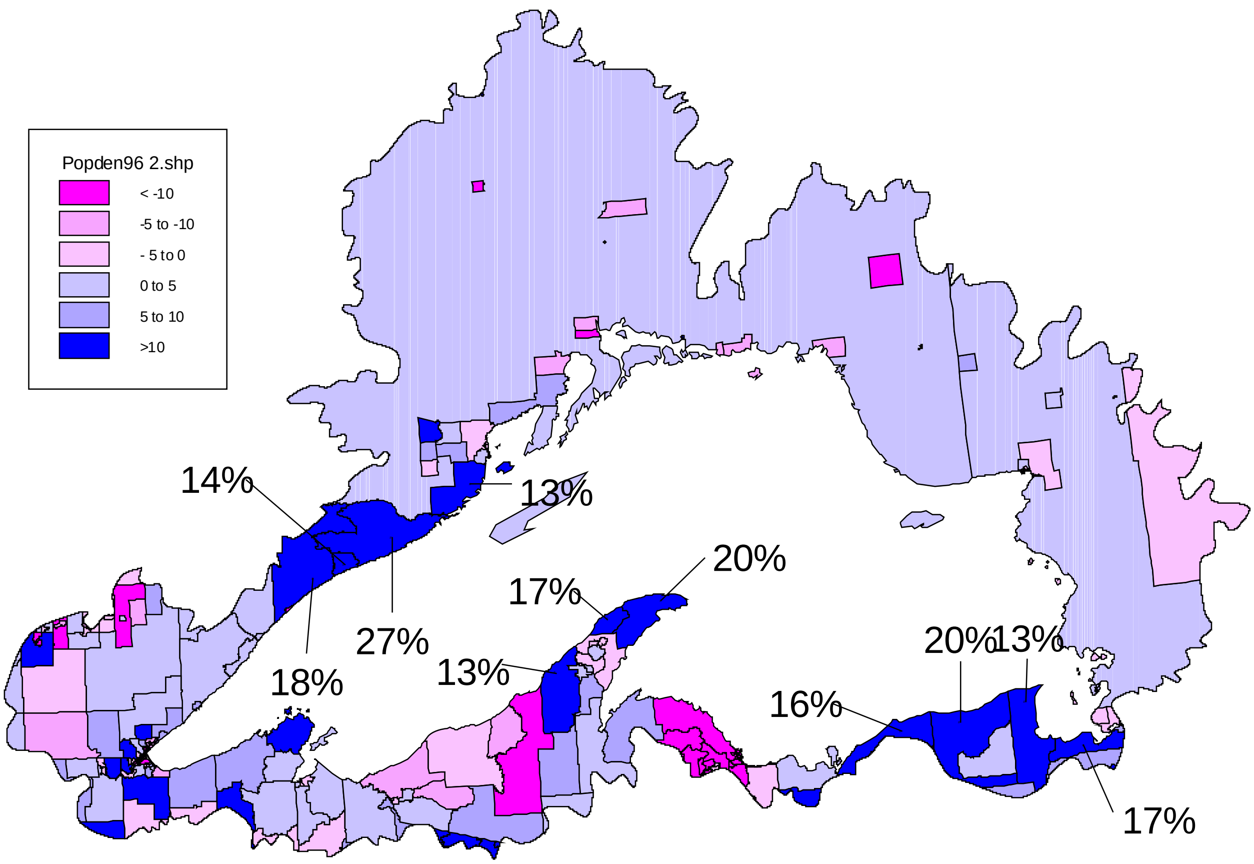


Figure 6-6. Population change (percent) between 1991 and 1996 (Lake Superior Decision Support Systems data, based on U.S. and Canadian census data)

6.1.1.4 Political Boundaries

The Lake Superior basin is divided between three states and one province (Table 6-2, Figure 6-7). Major cities are Sault Ste. Marie, Michigan/Ontario, Duluth/Superior, and Thunder Bay. Each of the states is divided into counties (7 in Minnesota, 5 in Wisconsin, and 11 in Michigan). The two districts in Ontario have no elected bodies or land management authority.

Figure 6-7. Counties and districts of the Lake Superior basin

6.1.1.5 Land Use and Ownership

In the U.S., approximately 54 percent of the land base in the basin is privately owned. The remainder is public land held by various agencies of the federal (National Forest Service, National Parks Service, Wildlife Service), states (Department of Natural Resources), and county governments in Michigan, Minnesota and Wisconsin (Table 6-2). A number of tribal reservations are also found within the Lake Superior basin. Information summarizing the number, size, and distribution of reservations and tribal lands is currently being compiled. Note that tribal land in Michigan is not yet included in Table 6-2.

In Ontario, land ownership is primarily in the public domain, amounting to about 90 percent of the area. The Ontario Government holds this as Crown Land and Provincial Parks. The remaining 10 percent is held in private ownership (Figure 6-8). The majority of this land is held in relatively small holdings in the form of farmland, city and rural residential lots, and mining developments. There are some large consolidated blocks of land, which are privately held by railway and pulp and paper companies. Tribal Land and Indian Reservations make up less than 1 percent of the land base and are included in the 10 percent. Reservations in the basin also contain lands that are not public. These areas are not yet accurately identified in Figure 6-8.

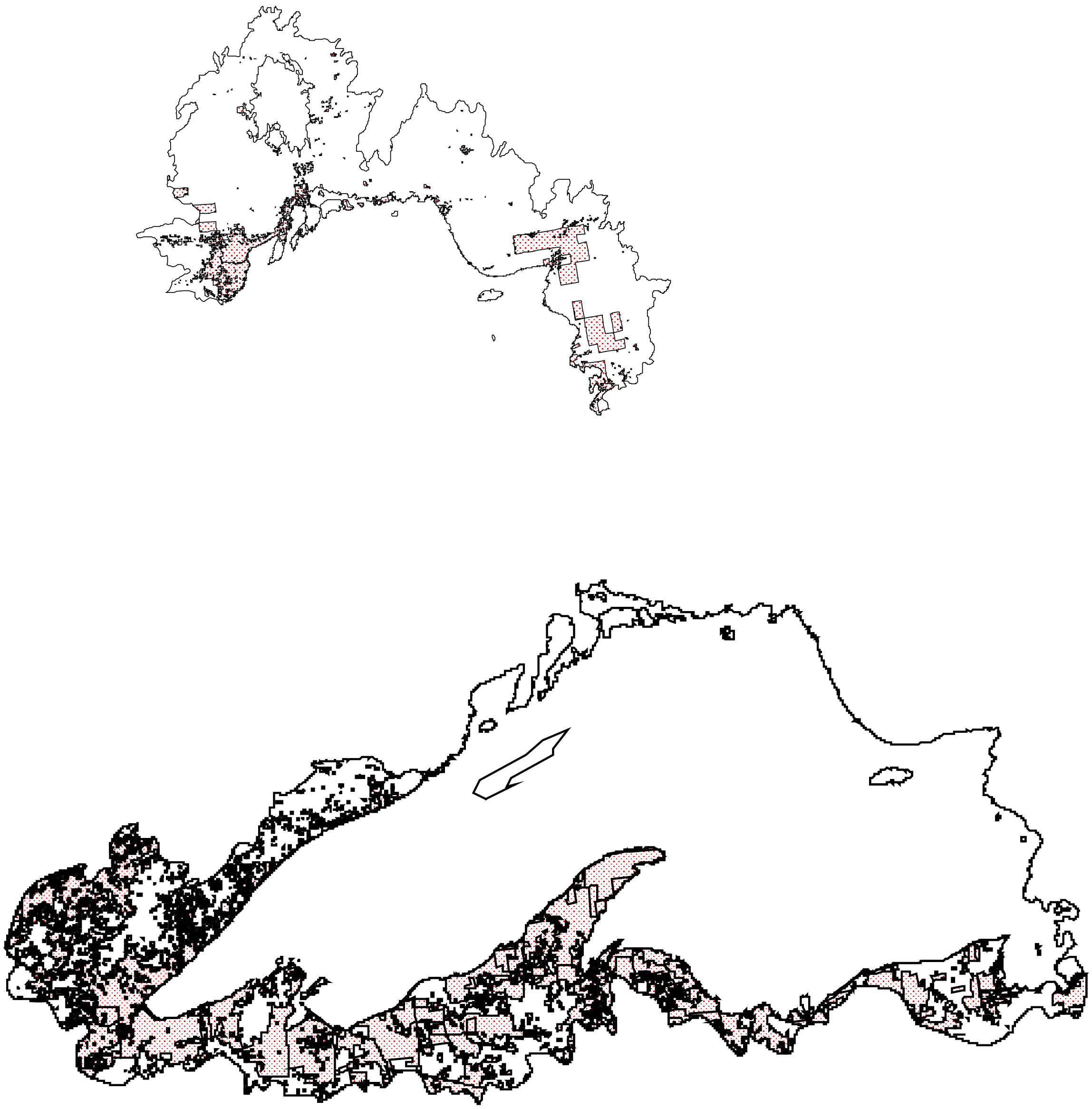


Figure 6-8. Private Land (pink) in the Lake Superior Basin (derived from OMNR and Lake Superior Decision Support Systems data)

Table 6-2 Land Ownership in the Lake Superior basin
("+" indicates < 1 percent)
(derived from OMNR and Lake Superior Decision Support Systems data)

Ownership	**Ontario**		**Michigan**		**Minnesota**		**Wisconsin**		**Total**	
	km²	**%**	**km²**	**%**	**km²**	**%**	**km²**	**%**	**km²**	**%**
County Forest			152	1	3603	22	1376	19	5,131	4
National Forest			4139	20	2706	17	1061	15	7,906	7
National Park	1878	2	649	3	1	+	146	2	2,674	2
Other Federal			59	+					59	+
Other Private /Unclassified*	9067	12	8322	41	6081	38	3950	55	27,420	22
Non-industrial Private Forest					22	+			22	+
Private Industrial Forest			4435	22	482	3	341	5	5,258	4
Crown Land / State Forest	59,195	75	2338	11	2039	13	131	2	63,703	52
State / Provincial Park	3229	4	364	2	155	1	28	+	3,776	3
Conservation Reserve	5052	6							5,052	4
State Fish & Wildlife					130	1	28	+	158	+
Other State					94	1			94	+
Tribal					203	1	70	1	273	+
Army Corps of Engineers					1	+			1	+
Bureau of Indian Affairs					61	+			61	+
Bureau of Land Management					13	+			13	+
Wilderness Area					565	3			565	1
Total Area	**78421**	**100**	**20458**	**100**	**16156**	**100**	**7131**	**100**	**122,166**	**100**
Percent Area	**64 %**		**17 %**		**13 %**		**6 %**		**100 %**	

* includes Patent Land in Ontario

Note: Data presented for Michigan is incomplete. Missing data will be added in later drafts of the habitat chapter.

6.1.1.6 Parks and Protected Areas

The Lake Superior basin has approximately 10 percent of the area in parks and protected areas (see Figure 6-9). For purposes of this report, protection has been interpreted broadly. Areas included range from Wilderness Class National and Provincial Parks to national forest areas and state parks. There are at least 112 areas ranging in size from Wabakimi Provincial Park (< 890,000 ha; only part of which is within the basin) to Baraga State Park (22 ha) in Michigan.

In the last few years significant steps have been taken to improve the areas under protection around the lake. “Ontario’s Living Legacy” has identified many new areas for new or additions to existing parks. In addition, policies are being put in place to recognize the Great Lakes Heritage Coast. This policy will recognize the “internationally significant natural, cultural, scenic, and recreational values of the Lake Superior shoreline.” This policy will apply to all Crown lands, waters, lakebeds, Crown islands, and intervening coastal areas between the Pigeon River mouth and the St. Mary’s River at Sault Ste. Marie. The policy does not apply to Indian Reserves or private land.

Lands designated under “Ontario’s Living Legacy” has three land use categories proposed for it, provincial Parks, Conservation Reserves & Enhanced Management Areas. In total this provides an area of 3856 km^2 of varying degrees of protection.

On the south shore of the lake there are two National Lakeshore, a National Park, many State Parks which provide protection for specific sites, and parts of five National Forests which are managed for forestry and recreation, as well as providing some wilderness representation. In addition, part of the Boundary Waters Wilderness Area is within the Superior National Forest (Table 6-3).

Even with this high level of protected areas there are still areas that need to be considered. World Wildlife Fund Canada (1999), concludes that “… there remain significant gaps in the core protected areas system for the Lake Superior basin in both the terrestrial and aquatic portions, and both in the United States and Canada.” The study indicates that 12 of 29 seascapes have a marginal degree of protection, which includes five areas with at least 10 percent protection the remaining 24 have less than 5 percent protection.

The report calls for continued effort from existing processes and agencies {(eg. Ontario’s Living Legacy, Government of Ontario), the National Marine Conservation Area program (Heritage Canada), and Lake Superior Binational Program} to identify new candidate protected areas which would add to the ecological representation of the natural regions. And specifically to the enduring features and seascapes that have been identified in the WWF Canada Gap analysis.

Table 6-3 Parks and protected areas in the U.S. Lake Superior basin

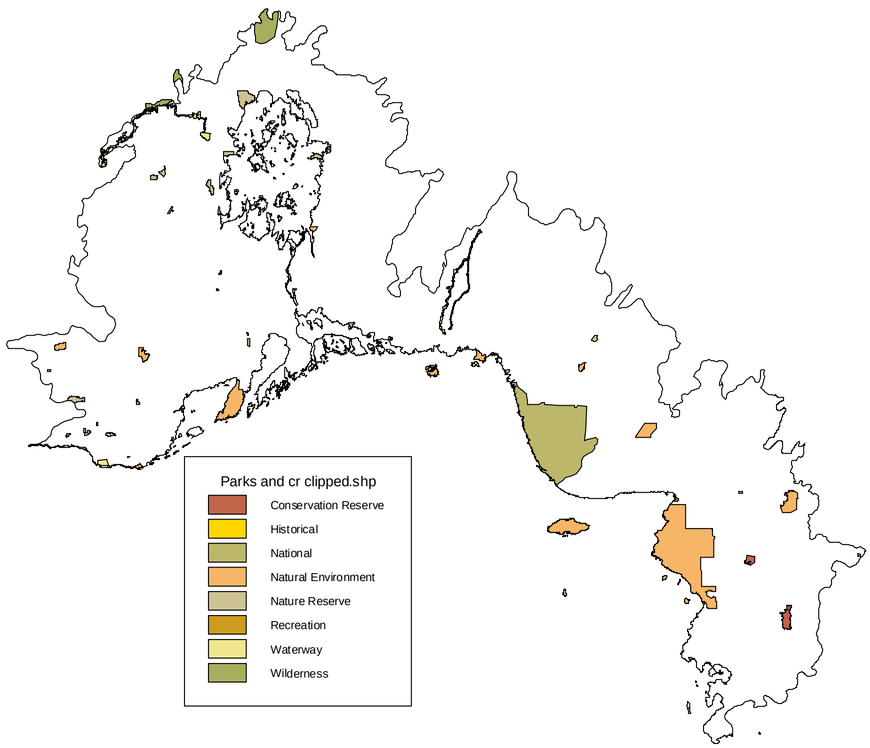
	Michigan	Wisconsin	Minnesota	Total
National Parks	1			1
National Monument			1	1
Wilderness (Forest Service)			1	1
National Lakeshore	1	1		2
National Historic Park	1			1
State Parks	13	4	13	30
State Wayside			3	3
County Parks			2	2
Wilderness Area	1			1

6.1.2 The Aquatic Environment

6.1.2.1 Bathymetry and Basin Morphology

Lake Superior averages 147 m in depth with a maximum depth of 406 m. The lake is divided into three main bathymetric basins by the Keweenaw Peninsula, which protrudes approximately 95 km into the lake from the southern shore (Figure 6-10). The eastern basin is characterized by a series of long, parallel, steep-sided troughs 100 to 300 m in depth which are oriented north-south. The central basin is comprised of very deep (up to 400 m), steep-sided sub-basins bounded on the north extensive underwater cliffs which fringe a complex series of islands. The western basin encompasses relatively shallower offshore waters and a very deep channel, the Thunder Bay Trough, which separates Isle Royale from the adjacent mainland.

Water depths of less than 100 m are found in a narrow band paralleling the shore, with a rapid fall-off to deeper waters. In addition, water depths of less than 100 m are also found around islands and off shore shoals, especially in eastern Lake Superior. Shoals are numerous along the eastern shore and northern shore, and Superior Shoal is prominent midlake as an extension of the Keweenaw Sill. Along the north shore, the Sibley and Black Bay Peninsulas, and associated islands, delineate three large, sheltered bays, Thunder Bay, Black Bay, and Nipigon Bay



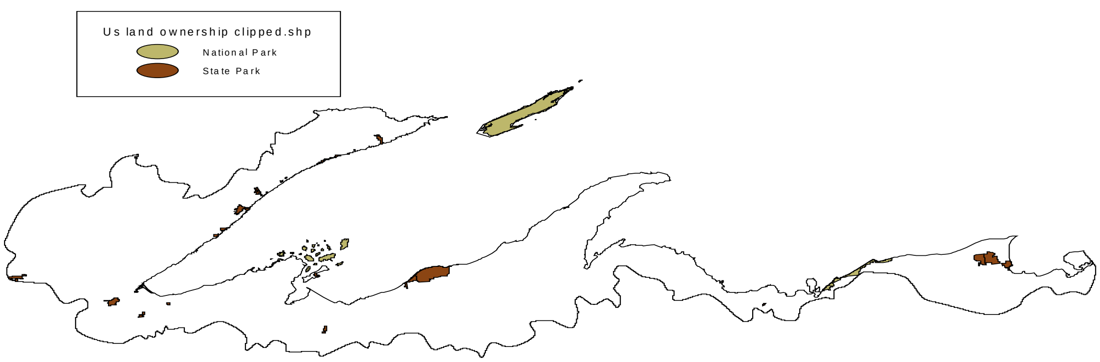


Figure 6-9. Parks and protected areas

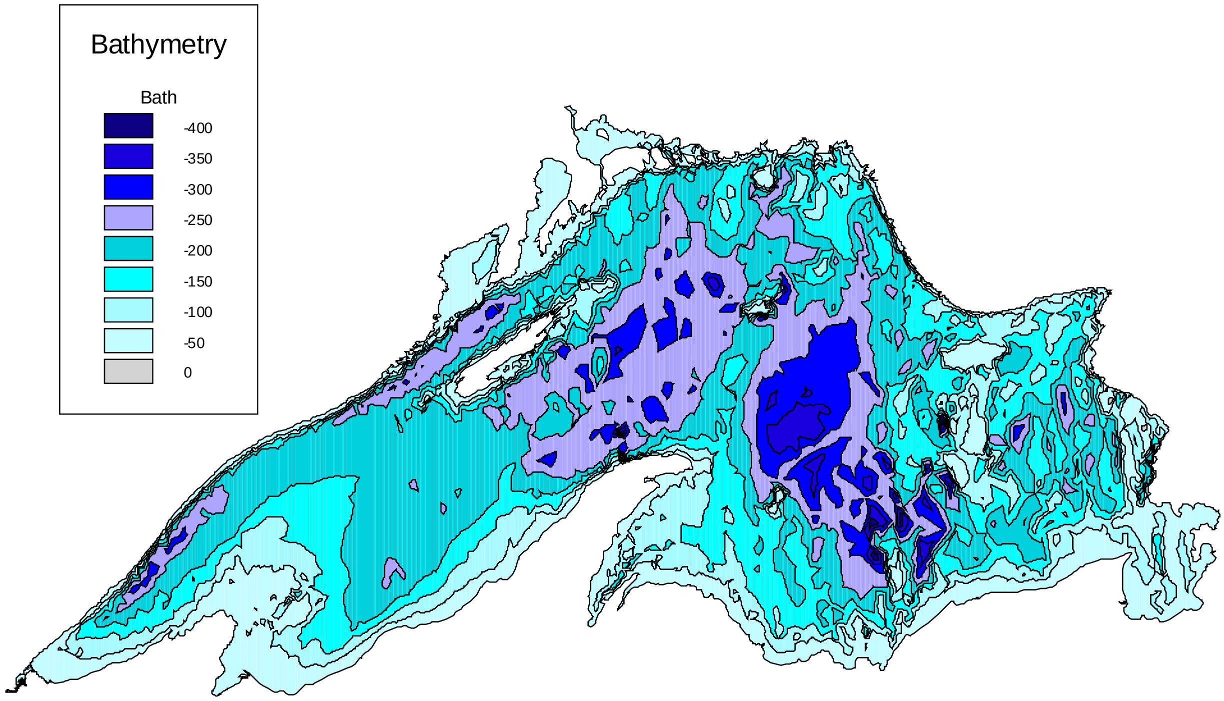


Figure 6-10. Lake Superior bathymetry

6.1.2.2 Sediments

Lacustrine sediments in Lake Superior reflect both glacial and post-glacial processes. Most of the existing sediments in Lake Superior were deposited approximately 11,000 to 9200 BP while the last Wisonsinan glacier was still within the lake's drainage basin (Thomas and Dell 1978). These glaciolacustrine sediments were derived directly from the melting ice front or from meltwater streams flowing into the lake. Till deposited during the last period of glaciation often underlie these glaciolacustrine sediments. The average thickness of glaciolacustrine sediments is approximately 1 m, but can be more than 18 m in northern parts of the lake (Thomas and Dell 1978). Massive red calcareous clays predominate in the lower strata and usually grade upward into red or grey carved calcareous clays. Red clays are derived from red tills from the southwestern portion of the basin, whereas grey clays reflect tills from the northeastern part of the basin exposed later as the glacier retreated. These sediments are comprised mainly of clay minerals, quartz, feldspars, calcite and dolomite (Dell 1973). The calcite and dolomite are derived from calcareous Paleozoic rocks of the Hudson Bay lowland that were originally deposited as tills around the lake. In late glacial times, sedimentation rates in Lake Superior were so high (up to 13 cm/yr) that carbonates were preserved in sediments beneath the top few cm (Thomas and Dell 1978). Unless the sediments are reworked by contemporary processes (e.g. currents), the carbonates remain in equilibrium with interstitial water and are preserved.

Postglacial sediments from deposition within the last 9200 years overlie glaciolacustrine sediments in most of the lake. Little or no postglacial deposition has occurred in some parts of the lake, especially in nearshore areas, and glacial till or glaciolacustrine sediments are exposed or nearly so. For most of the lake however, post-glacial deposits average 3 m in depth, but may be as much as 9 m in local basin-like depressions (e.g. Thunder Bay Trough). These post-glacial sediments are primarily reddish brown or greyish-brown silty clays in the southern portion of the lake, grading to darker greys in the north. Postglacial sediments in Lake Superior are non-calcareous, even though they are derived from calcareous tills or glaciolacustrine sediments, since modern sedimentation rates are slow enough to allow complete dissolution of calcite and dolomite. Much of the Superior shoreline is rocky and therefore contemporary deposition rates average less than 2 mm per year (Bruland and others 1975). Much of the lacustrine sediment currently being deposited in Lake Superior may be reworked material derived from subaqueous erosion by currents.

Modern surficial sediment distribution in Lake Superior (Figure 6-11) is related to bathymetry, circulation patterns and proximity of terrestrial sediment source. Deposition of very fine-grained muds occurs in deeper basins and local topographic depressions, resulting in exceptionally thick deposits in northern portions of the lake. Tills and glaciolacustrine clays are exposed and possibly eroded (Dell 1974) in non-depositional zones that occur around the lake periphery and in areas of high local topographic relief (even if they occur in deep water). Exposed bedrock occurs in a few locations close to shore, in island areas and regions of high lake bottom relief. Organic carbon in Lake Superior sediments ranges from only 0.01 to 3.85 percent reflecting the oligotrophic nature of the lake, and is greatest in depositional zones.

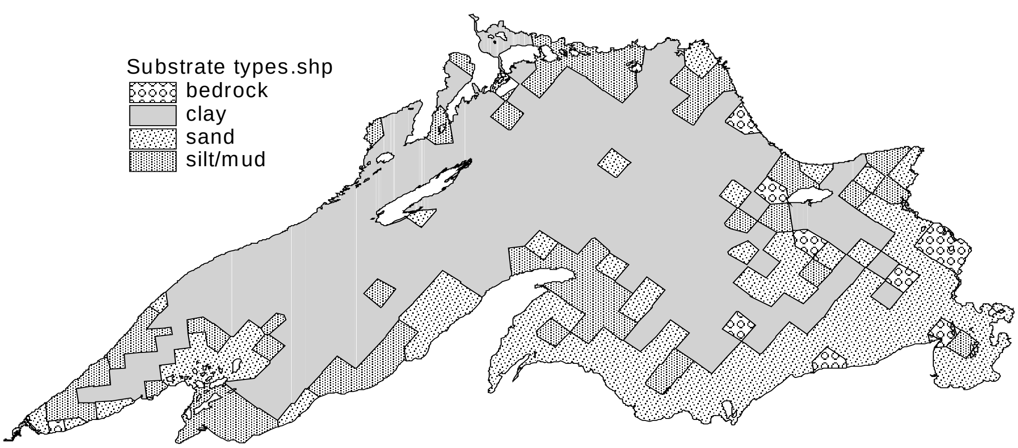


Figure 6-11. Surface sediment distribution in Lake Superior (after Thomas and Dell 1978)

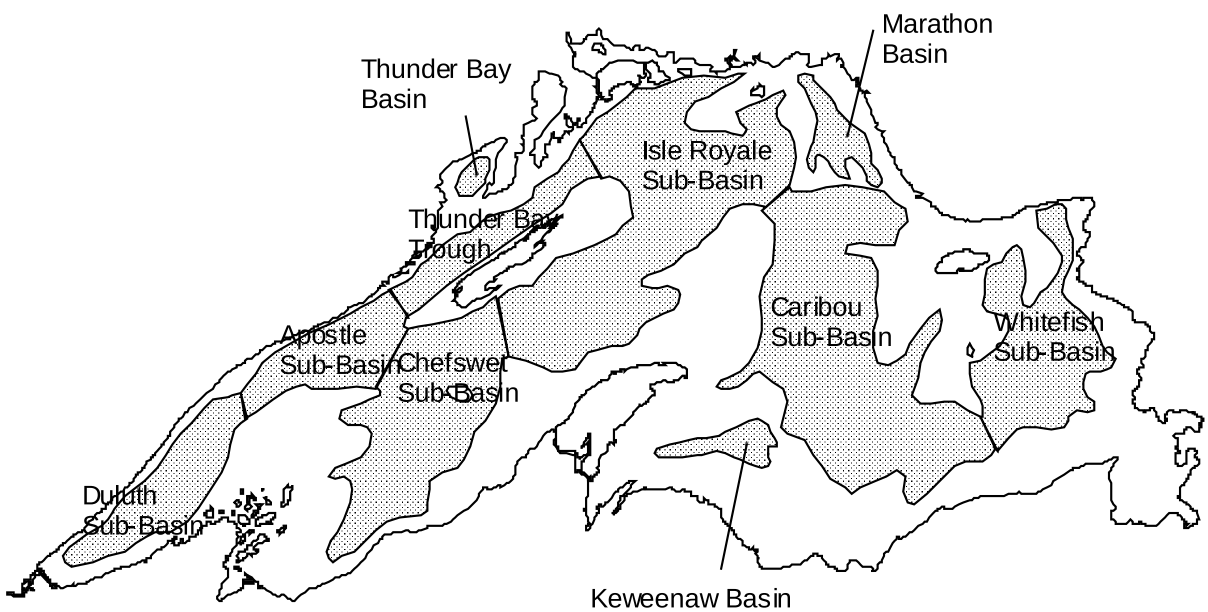


Figure 6-12. Depositional basins (shaded) (IJC 1977)

6.1.2.3 Sedimentation and Turbidity

Modern sedimentation rates are generally half the magnitude of postglacial sedimentation rates and range from 0.1 to 2.0 mm per year. This is equivalent to approximately 6.029 million tonnes of fine sediment annually (Kemp and others 1978). Sedimentation rates vary with proximity to terrestrial source, circulation patterns and bottom topography. The highest rates are found at locations closest to the edges of depositional basins and at the base of step-sided troughs, and lowest midlake in areas of gentle topography. Shoreline erosion is the largest external source of sediment (Table 6-4), with the red-clay district on the western shore of the Keweenaw contributing up to 58 percent of annual inputs (Kemp and others 1978). Due to circulation patterns, suspension and deposition of these particles is likely to remain in the vicinity of the Duluth basin and western shore of the Keweenaw Peninsula. Approximately 37 percent of the current natural sediment load is deposited in the Duluth basin, followed by the Chefswet and Keweenaw basins (Kemp and others 1978).

Lake Superior tributaries are the second most important source of sediments with 30 percent of total inputs (IJC 1977). The St. Louis and Ontonagon rivers are the largest American sources, and the Nipigon, Kaministiquia and Pic rivers are the largest Canadian sources, although much of this settles in Nipigon Bay and Thunder Bay (Kemp and others 1978). Erosion of taconite tailings from Silver Bay, Minnesota account for 7 percent of the fine-grained sediment input. Although, annual loading of airborne particulates is low relative to other sources, these particles are of great importance because of their high concentrations of toxins and nutrients.

Table 6-4 Estimated quantity of clay and silt-sized sediment inputs to Lake Superior from various sources (adapted from Kemp and others 1978)

Source	Yield (metric tons)
Shoreline erosion	4,640,00
Taconite tailings	339,00
River inputs	2,410,00
Airborne particulates	41,00
Autochthonous organic matter	200,000
Dredged spoils	210,00
Subaqueous erosion	?

Secchi depths range from 9-15 m in midlake and 5-11 m in nearshore areas. In southwestern Lake Superior, higher turbidity is due to increased suspended inorganic particulate concentration resulting from high erosion rates after ice break-up, agitation of sediments in the shallower nearshore, and associated sediments in water discharged as runoff from the surrounding basin (Stortz and others 1976). Secchi depths may be a low as 1.5-2.8 m under these conditions. Thunder Bay and Nipigon, and Black bay also have reduced water transparency.

6.1.2.4 Currents and Circulation

In Lake Superior, epilimnetic and hypolimnetic currents generally flow parallel to the shore in a counter-clockwise direction. There are also smaller gyres south of Isle Royale and around the Superior Shoal that reflect the bottom topography, temperature and wind conditions of those areas. Currents are stronger along the south shore than elsewhere in the lake and are greatest adjacent to the near the north side of the Keweenaw Peninsula (Keweenaw Current). Currents are affected by wind conditions and internal pressured caused by density variations and the slope of the thermocline. Less dense warmer water along the south coast where the thermocline is deeper show higher shoreline currents. Northerly hypolimnetic flows in the eastern portion of the lake may exceed 5 cm/sec compared to less than 1 cm/sec near Duluth and the Apostle Is. The magnitudes of the currents also vary temporally, with the largest currents occurring in September (Lam 1978). Currents also flow during winter when the coldest and least dense water is confined on the periphery of the lake.

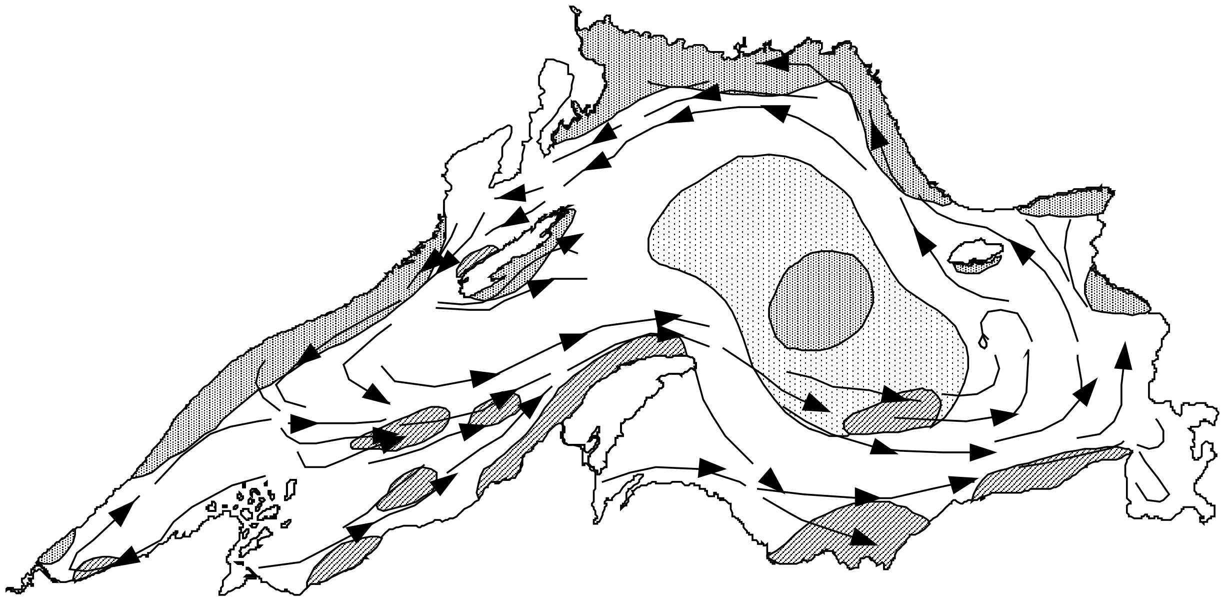


Figure 6-13. Major surface currents and upwellings
Downward water movement (cross-hatched), significant areas of upwelling (dark stipple) and extent of central upwelling (light stipple) are shown (after Harrington 1985 and WWF 1999)

Summer circulation is strongly influenced by the seasonal development and depth of the thermocline. During spring warming, current speeds are relatively constant, low and uniformly distributed throughout the water column. After stratification, mean current speed rises in the epilimnion (at 10 m depth), and attains maximum values in early September, one or two weeks after surface temperatures peak (Bennet 1978). The thermocline restricts downward transport of heat and momentum from the surface, so currents speed in the hypolimnion decrease slightly because of frictional dissipation and are a seasonal minimum in August. Current speed and temperature rises in September due to enhanced vertical mixing which provides a downward flux of heat and momentum. Epilimnetic water temperature and current speeds have a corresponding decline in September and October.

Strong modeled hypolimnetic currents in the vicinity of Superior Shoal, south of Isle Royale and east of the Apostle Islands are likely related to upwelling and downwelling (Lam 1978). Upwelling occurs where sub-surface water is brought to the surface of the lake to replace surface water that has been forced to move laterally by wind or the temperature-density pressure gradient. During the summer, surface water tends to flow away from the nearshore upwelling zone along the north shore of Lake Superior and towards the nearshore downwelling zone along the southern shore (Bennet 1978). The general shoreward drift of surface water associated with anticlockwise flow contributes to upwelling in midlake, as do bottom topography, rapid heating of the water and winds. Upwelling enhances heat exchange by allowing more heat to enter the water during the summer and more to escape during the winter than if no upwelling occurred. Upwelling may bring nutrients and organic matter from the lake bottom and hypolimnium into more biologically active surface waters, which tends to increase productivity. See Figure 6-13 for major surface currents and upwellings in Lake Superior.

6.1.2.5 Temperature

Water temperature is of paramount importance since it affects rates of chemical and biological processes and the thermal regime influences patterns of currents and density structure, as well as vertical and horizontal mixing. Lake Superior has a unique thermal regime due to its size and has the lowest summer surface temperature (13°C) and mean annual lake temperature (3.6°C) of the Great Lakes (Bennet 1978). Lake Superior has a semi-annual alternation between periods of stratification and of extensive vertical mixing typical of dimictic lakes (Figure 6-14). Although the annual heat income of Lake Superior is the second highest for any lake in the world, winter heat lost is the highest of the Great Lakes, and approximately half is used for spring warming of the lake to the temperature of maximum density (~3.8°C). As a result, the spring convective mixing period is longest of the Great Lakes, the summer stratification period the shortest, and the maximum surface temperature in the summer the lowest. There is great year-to-year variation in the surface temperature of Lake Superior, especially in the summer months. The epilimnion is relatively deep in years when the mean surface temperature is relatively low and vice versa.

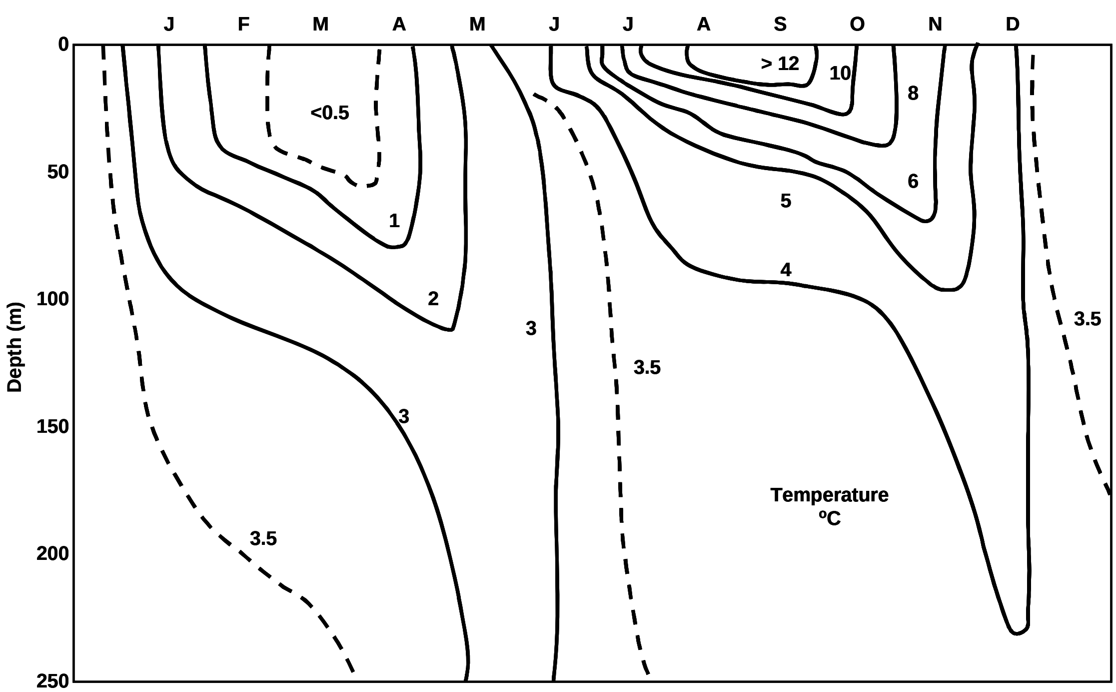


Figure 6-14. Seasonal changes in water temperature with depth for Lake Superior (Bennet 1978)

During winter stratification, the cooler (<1° C) waters of the epilimnion rest on denser, warmer water at a depth of 40 to 60 m. The lowest mean lake temperature of 1.4 ° C occurs at the April. Rapid warming from increased spring solar radiation raises surface water temperatures from 0°C at the end of March to 3.0° C by early June. The vigorous convective mixing results in a rapid downward flux of heat from the lake surface and the beginning of heating of the entire lake volume. This extends the epilimnion to a depth of 250 m or more by early June. By mid-July, surface waters have warmed past 4°C across the entire lake (including midlake), and initial summer stratification occurs. Surface temperatures then rise rapidly and the thermocline develops at a depth of approximately 10 m, which effectively reduces further transfer of heat and momentum to the hypolimnion. Surface temperatures continue to rise and reach a maximum of approximately 13°C in September, and mean lake temperature peaks at 5.8 ° C. Temperatures in the hypolimnion remain fairly constant throughout the summer at about 4° C. Beginning in mid-September, the epilimnion begins to extend downward due to autumnal cooling and enhanced vertical mixing and by the end of summer stratification in late November, the epilimnion has extended to 145 m. Convective mixing develops in November and slows the rate of decrease of surface temperature. By the end of December surface water have dropped to 3°C, and decline rapidly in January as the lake stratifies.

Horizontal temperature patterns (Figure 6-15) are due to differences in the local seasonal cycle of heating and cooling of the upper layer. Rapid inshore warming causes the formation of a thermal bar in the spring, which traps less dense warm water until it has reached 4°C. Surface temperature rises relatively rapidly and attains the highest values in Whitefish Bay, while spring warming is slowest and maximum summer temperature is relatively late and low in midlake (Irbe 1991). Coastal upwelling along the northwest coast maintains low temperatures until late June, similar to the midlake condition. As vertical stratification occurs in July, there is rapid warming along the northwest coast from 6°C to 14-16°C resulting from the formation and offshore movement of the thermal bar. During the winter, horizontal water temperature patterns are reversed, with cold water on the periphery of the lake, particularly along the south shore, and warm water located along the northwest coast and mid lake (Leshkevich 1975).

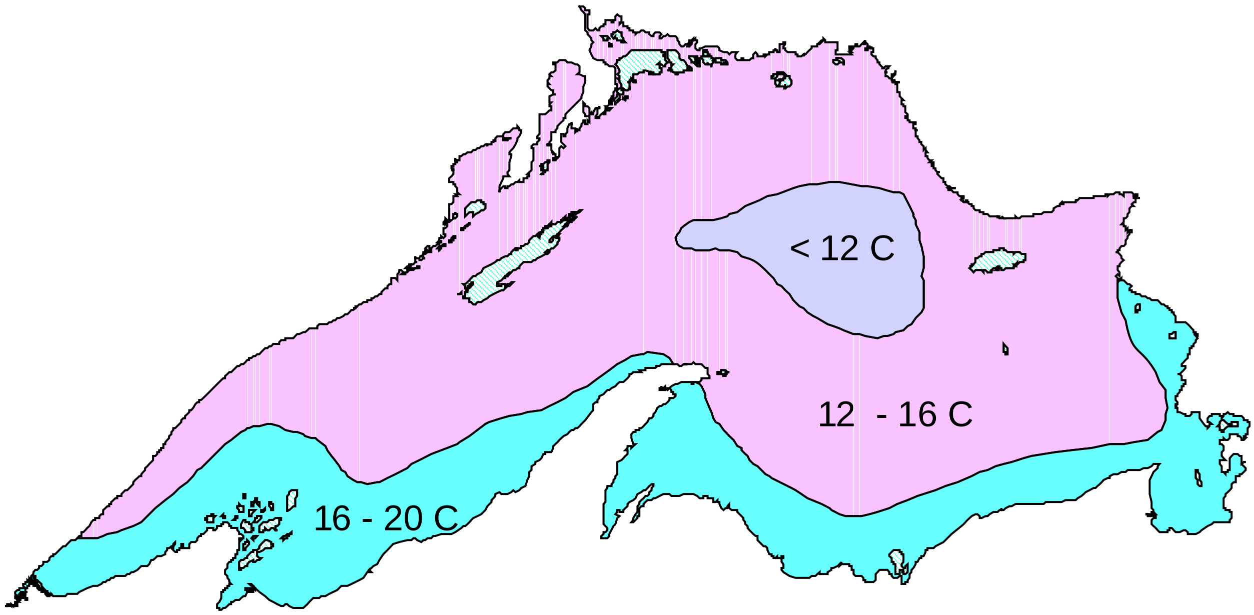


Figure 6-15. Mean August surface water temperature for Lake Superior

6.1.2.6 Ice Cover

Ice cover has considerable environmental impacts such as providing insulation between the atmosphere and relatively warm water, thereby reducing heat loss, evaporation, and the occurrence of lake-effect snowstorms. It may also impact upon fish reproduction (e.g. ling) and dispersal of terrestrial mammals to islands (e.g. caribou and wolves on the Slate Islands). During a mild winter, approximately 40 percent of the lake surface is expected to become ice-covered, compared to 60 percent during a normal winter and 95 percent during a severe winter (Rondy 1971). Maximum ice cover normally occurs in late March (Figure 6-16). At this time, consolidated pack ice occurs in most of the shallow bays and along much of the north shore. Close pack ice (70-90 percent cover) exists over the middle portion of the lake and approximately 40 percent of the Lake is open water, mainly in the eastern end around Caribou Island. Leads occur off Montreal Shoal, the Apostle Islands, the Keweenaw Peninsula and between Isle Royale and the Slate Islands. These leads are used by gulls and bald eagles during migration or local movement.

Water circulation has a strong impact upon ice cover. Midlake upwelling that is present during the open-water season is maintained throughout the winter by rapid heat loss. This keeps the central area free of ice, which in turn results in a large integrated winter heat loss (Bennet 1978). The winter upwelling of relatively warm water is responsible for the lack of fast ice along the open part of the northwest shore (Marshall 1968).

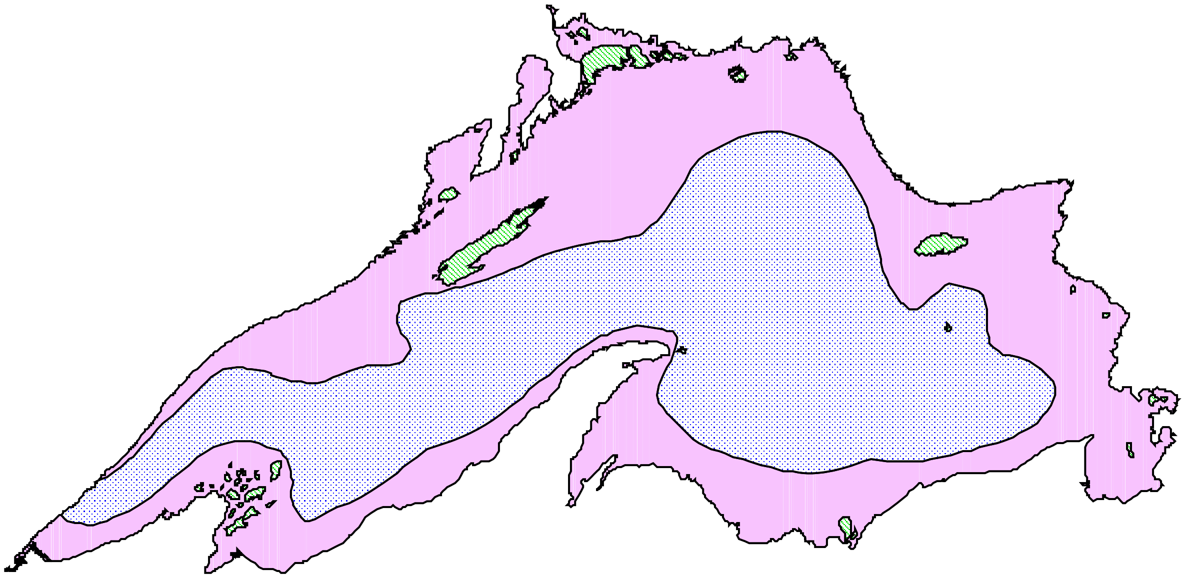


Figure 6-16. Normal winter maximum ice cover for Lake Superior (Rondy 1971)

6.1.2.7 Nutrients

Lake Superior has been classified as an ultra-oligotrophic lake on the basis of its very low nutrient availability and cold temperature. The water chemistry of Lake Superior is determined by the geology and climate of its drainage basin, anthropogenic inputs, bottom topography, circulation patterns, thermal regime, and biological processes. Lake Superior is characterized by high concentrations of total nitrogen and reactive silicate but very low concentrations of total phosphorous, which limits productivity (IJC 1976). Nutrient levels are quite uniform horizontally and vertically in the open lake, with the exception of areas with restricted circulation, notably western end near Duluth, Thunder Bay and Whitefish Bay. Nearshore areas, near Duluth in particular, exhibit generally elevated levels of total phosphorus and silica that are linked to man-made and riverine inputs (Weiler 1978). Locally elevated nutrient concentrations have also been identified in Thunder Bay, the Carp River mouth and Munising. Nitrate and silica have well-defined seasonal cycles correlated with biological uptake and release. They usually reach a minimum during August and September when phytoplankton biomass peaks. Current nitrate concentrations in Lake Superior are higher than historical levels, and are increasing at approximately 3 μg/L per year (Dobson 1972).

6.1.2.8 Oxygen

For most of the year, Lake Superior is saturated with dissolved oxygen. During the spring, convective mixing to nearly 300 m depth brings nearly all of the lake water in contact with the atmosphere (Bennet 1978). As a result, nearly the entire lake volume becomes saturated with dissolved oxygen. Some oxygen depletion can occur locally, but dissolved oxygen levels remain over 80 percent (Matheson and Munawar 1978). There is also a small loss of oxygen from the hypolimnion caused by the oxidation of organic matter that has settled through the thermocline. However, the great depth, low productivity, and the persistence of vertical mixing through June precludes the possibility of any deleterious effects of biological oxygen demand (BOD) in deep water. In addition, the relative shortness of the summer stratified period (approximately four months compared to five months for Lake Ontario), in principle results in a lower seasonal BOD per unit area of the hypolimnion. BOD per unit volume would also be comparatively lower due the large thickness of the hypolimnion in Lake Superior compared to the other Great Lakes.

6.1.2.9 Primary Production - Chlorophyll *a*

Chlorophyll *a* concentrations, which are a measure of phytoplankton biomass, reflect the levels of nutrients, particularly total nitrogen and phosphorous. In offshore areas, chlorophyll *a* levels seldom exceed 1 μg/L, except in the western end of the lake near Duluth. Higher chlorophyll *a* concentrations are found in nearshore areas, ranging on average from 0.6 to 2.5 μg/L, with Duluth-Superior Harbour showing even the highest levels (3.6 μg/L). If greater quantities of phosphorous become available, there is the potential for a significant increase in productivity due to the overabundance of nitrate and reactive silicate in offshore waters (IJC 1976).

Primary production by phytoplankton is strongly related to the depth to which photosynthetically active radiation penetrates the water surface i.e., the euphotic zone (Fee 1971). The euphotic zone averages 20-30 m depth in offshore areas, and less than 20 m in coastal areas near Duluth, Thunder Bay, Nipigon Bay, Black Bay, Marathon, Whitefish Bay, Apostle Is. and the southwest red clay portions of the lake. Near Duluth, the euphotic depth may be only 2 m deep. In general, Lake Superior has similar water transparency to Lake Huron, and both Upper Great Lakes have lower mean vertical extinction coefficients (MVEC) than the other Great Lakes (Schertzer and others 1978).

Lakewide chlorophyll *a* concentration decreases in mid-October due to the decline in solar radiation and decreased water temperatures associated with deep vertical mixing.
Water transparency varies spatially and temporally and is generally correlated with seasonal changes in chlorophyll *a* concentration.

6.1.2.10 Water Level Fluctuations

Lake Superior's water levels undergo natural variation at the short-term, seasonal and year-to-year scales (Edsall and Charlton 1997). Short-term variation takes place over the course of several hours, due to seiche activity (oscillation due to changes in barometric pressure or wind). The amplitude of variation is in the range of a few centimeters or tens of centimeters, but can exceed 1 m under extreme conditions (Edsall and Charlton 1997).

Seasonal changes in water levels occur in response to the annual cycle of precipitation and runoff. Lake Superior's levels typically peak in October and recede over the winter, reaching the lowest levels in early spring, followed by a steady rise through the spring and summer.

Year-to-year fluctuations result from year-to-year fluctuations in precipitation and runoff. Table 6-4a and Figure 6-17 show the natural water level fluctuations (represented by the 1860 – 1887 period) compared to current conditions (represented by data from 1900 – 1986). Lake Superior levels are now higher than they were under natural conditions, but show a smaller range of variation between maximum and minimum values (1.01 m vs 1.16 m) (Southam and Larsen 1990).

Water level fluctuations are important in maintaining healthy wetlands. Extreme low water levels allow cyclic, regenerative processes such as oxidation of sediments and germination of submerged seed banks to occur over a broad width of shoreline. High water levels prevent the encroachment of trees and shrubs in open wetlands (Wilcox and Maynard 1996). Effects of water level fluctuations on fish habitats are not well understood (Edsall and Charlton 1997).

Table 6-4a Mean water levels (m) under current and natural conditions (adapted from Southam and Larsen 1990)

	Current	Natural	Difference
Mean	183.00	182.91	+0.09
Maximum	183.46	183.43	+0.03
Minimum	182.45	182.27	+0.18
Range	1.01	1.16	-0.15

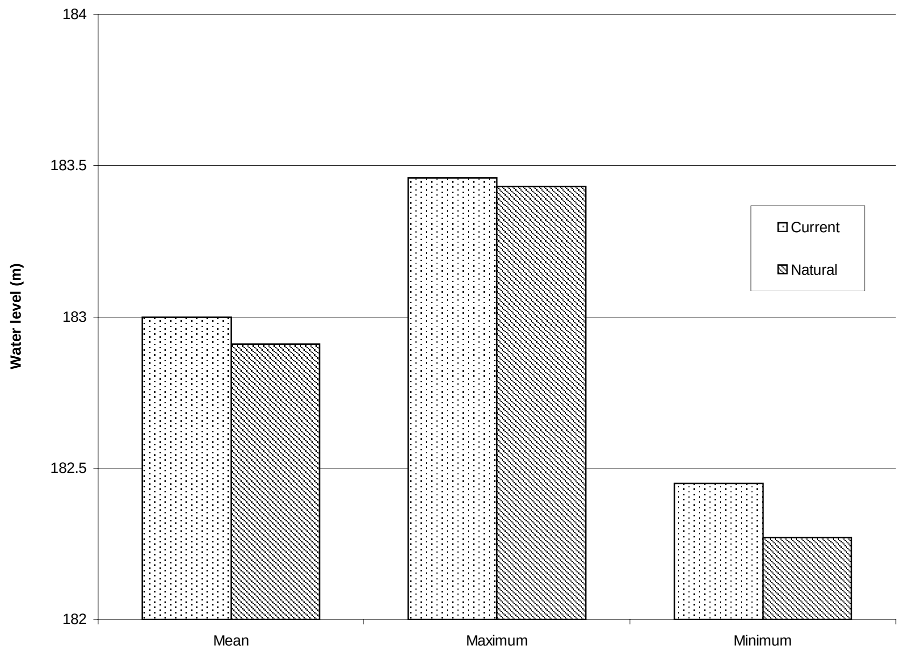


Figure 6-17. Annual water level fluctuations in Lake Superior, comparing present and natural values

6.1.2.11 Great Lakes Natural Regions and Seascapes

Great Lakes Natural Regions and Seascapes were developed as part of a classification system of enduring features for planning marine protected areas (World Wildlife Fund 1997). Natural regions and seascapes are equivalent to terrestrial ecoprovinces and ecodistricts respectively. Natural regions are delineated on the basis of light penetration and macrotopography. Lake Superior comprises 11 marine natural regions and 20 seascapes (Figure 6-18). The four benthic natural regions are subdivided into 13 seascapes on the basis of substrate type, slope and water motion (e.g. upwelling, stratification). The Photic Zone Natural Region #1 encompasses the entire benthic euphotic zone of Lake Superior, including significant offshore shoals. The West Slope Natural Region #2 lies on the windward side of the lake and is characterized by low relief at depth of about 150 m. The Central Basin Natural Region #3 is a deep basin (up to 400 m) with upwelling zones. The Southeastern Rise Natural Region #4 characterized by very irregular bottom topography and depths from 100 to 300 m. The seven pelagic natural regions represent the euphotic (>20 m depth) and dysphotic-aphotic zones overlying the corresponding benthic natural region. Natural Region #1 has only one overly pelagic region (the euphotic zone), whereas the other three benthic natural regions each have two pelagic natural regions. The pelagic natural regions are not further divided so are also effectively seascapes.

Seascapes within the nearshore euphotic zone are defined on the basis of exposure to wave energy (i.e. exposed or protected) which is related to fetch direction and length, the presence or absence of offshore islands, and overall shoreline morphology. Offshore shoals and island shorelines are included with the adjacent mainland at this scale, even though they are often exposed to more wave energy. Seascapes in the offshore natural regions are delineated by water mixing and bottom substrate type (particle size).

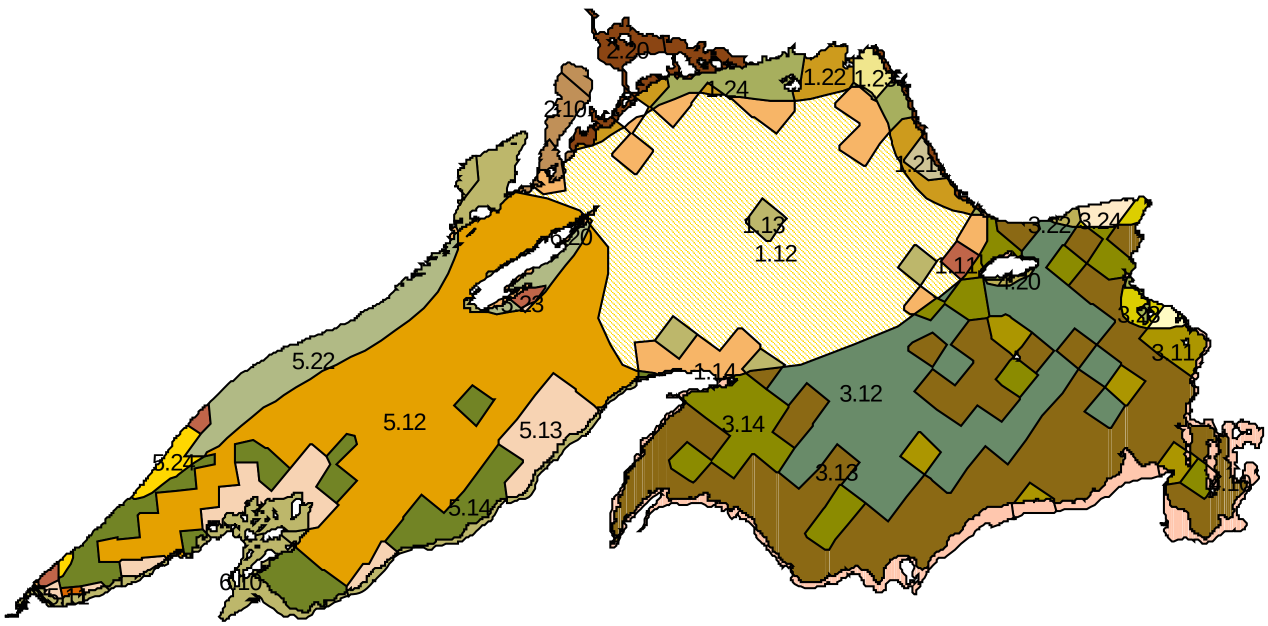


Figure 6-18. Seascapes of Lake Superior (World Wildlife Fund Canada 1999)

6.1.2.12 Nearshore Habitat and Embayments

Nearshore open water habitat consists of areas where the water depth is less than 80 m (Lake Superior Technical Committee 1999). Embayments (or bays) are partially enclosed by land and therefore less exposed to wind and wave energy. Together, these habitats make up about 20 percent of Lake Superior’s surface area.

A subset of the nearshore zone is the area where the thermocline intersects with the lakebed in late summer. In other words, this is the zone where the entire water column and the substrate are subject to seasonal warming and cooling. In Lake Superior, this is marked by about the 10 m depth (Edsall and Chalton 1997).

Nearshore waters consist of a narrow band along the north shore, but is generally wider along the south shore (Figure 6-19). The most extensive areas of nearshore habitat are at the east and west ends of the lake. Nearshore habitat is also found around Isle Royale and other islands and includes offshore shallow waters, such as the Superior Shoal and the Caribou Island Reef Complex. Major embayments include Black Bay, Nipigon Bay, Thunder Bay, Batchawana Bay, Whitefish Bay, Keweenaw Bay, and Chequamegon Bay.

Figure 6-19. Nearshore (dark) and offshore (light) habitats.

Despite their relatively small area, nearshore areas are important because they are more diverse and productive than offshore waters. Most of Lake Superior's fish species use nearshore waters at some stage of their life cycle and many commercially important fish use nearshore waters exclusively (Edsall and Charlton 1997). Nearshore habitats have warmer temperatures and greater diversity of substrate types than offshore areas. In exposed stretches, waves and currents clean the substrate of sediment, maintaining suitable spawning and nursery habitat for fish species (Figure 6-20). Aquatic vegetation is found only in nearshore habitats.

Table 6-5 shows nearshore areas and bays that have been identified as Aquatic Biodiversity Investment Areas (Koonce and others 1998). These are sites in the Lake Superior ecosystem that are especially productive, support exceptionally high biodiversity, support rare species or habitats and contribute significantly to the integrity of the whole ecosystem (Koonce and others 1998).

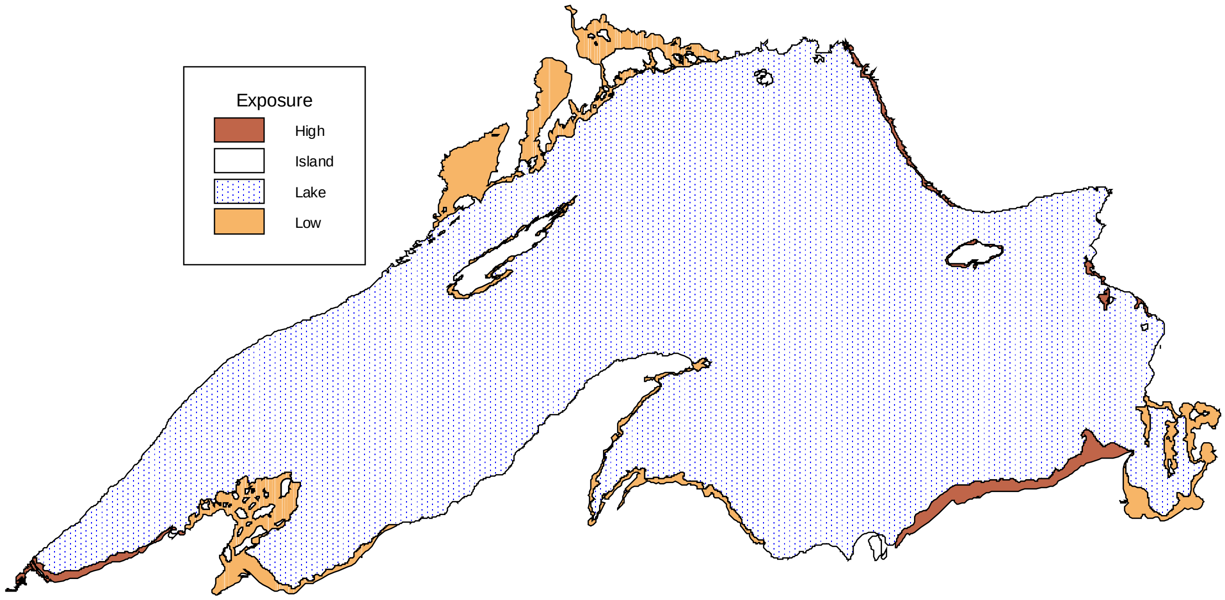


Figure 6-20. Wave exposure zones (WWF).

Nearshore habitats, especially bays, have been exposed to more impacts of human activities than offshore areas. Many of the bays are adjacent to intensive human use and are exposed to a variety of stresses. Loss of fish and wildlife habitat, primarily in the nearshore zone, has been identified at most of the Areas of Concern on Lake Superior.

Some nearshore waters have an accumulation of sawdust and woody debris associated with log drives and sawmills in the late 1800's and early 1900's, degrading spawning habitat for fish (Lawrey 1978). Embayments are also impacted by dredging, dumping of dredged material, and thermal loading. Exotic species, such as purple loose strife and ruffe affect the nearshore habitat.

Eutrophication, caused by nutrients input from sewage plants, industry and agriculture, results in algal blooms. This impairs visibility and decreases oxygen availability for aquatic life. On Lake Superior, eutrophication is a local problem on some bays, but algal mats have recently been discovered covering isolated rock shoals in Lake Superior (Edsall and others 1991).

Table 6-5 Nearshore waters and embayments nominated as Aquatic Biodiversity Investment Areas (adapted from Koonce and others 1998)

Site Name	Features	High biodiversity	High productivity	Critical for economically important species	Rare habitat features	Critical for rare species	Critical for endangered species	High habitat diversity
Allouez Bay	Embayment	X		X	X			
Batchewana Bay	Embayment	X	X			X		
Big Bay Reef	Nearshore reef, offshore reef		X	X			X	
Black Bay	Embayment	X	X	X				
Caribou Island Reef Complex	Offshore reef	X	X					X
Eagle River Shoals	Offshore reef		X	X	X			
Huron Islands	Offshore reef		X	X				X
Huron River Reef	Nearshore reef		X	X	X			
Isle Royale Nearshore Waters	Nearshore reef, embayment	X				X		X
Manitou Island	Nearshore reef			X	X	X		
Nipigon Bay	Embayment	X		X		X		
Otter Cove	Embayment	X	X		X			
St. Louis River	Embayment		X			X	X	
Thunder Bay	Embayment, nearshore reef	X			X			
Traverse Island Reef	Offshore reef		X	X				X

6.1.2.13 Offshore Habitat

Offshore habitat is deeper than 80 m. This habitat makes up about 80 percent of the surface area of Lake Superior (Figure 6-19).

Offshore habitats are less productive and diverse than nearshore habitats. Communities made up of a few species of pelagic and bottom-dwelling fish. The benthic habitat is dark and has a constant temperature of $4^{o}C$

Offshore habitats in Lake Superior are generally regarded to be healthy (LSBP 1998). Dumping or discharges from vessels may threaten habitat, but the impacts are not well understood.

6.1.3 Aquatic Communities

6.1.3.1 Phytoplankton

The Lake Superior phytoplankton community represents a unique assemblage of approximately 300 species. Scientific names of all species presented in this chapter can be found in Addendum 6-G. Nannoplankton (<60 µm) dominate the phytoplankton biomass and primary production, but most surveys have focused on diatoms and other net plankton (>60µm) (Munawar and others 1978). Phytoflagellates (cryptomonads, chrysomonads, dinoflagellates) comprise approximately 35 percent of the species, followed by diatoms (31 percent) and Chlorophyta (22 percent).

Lake Superior has been divided into six phytoplankton regions based on taxonomic and biophysical data (Munawar and Munawar 1978) (Figure 6-21) The Duluth, Thunder Bay, and Whitefish Bay regions are unique environments and show relatively high biomass concentrations during the summer (July-September) compared to other regions of the lake. With the exception of Duluth region, species composition is broadly similar among regions.

Common phytoflagellate species typical of oligotrophic lakes (e.g. *Cyclotell*a spp. and *Fragilaria crotonensis*) characterize the open lake. There are also a large number of rare species, some of which are indicative of cold-stenothermal oligotrophic conditions (e.g. *Stelexmonas dichotoma* and *Chrysolykos planctonicus*). The phytoplankton community in the Duluth region has fewer species and is dominated by diatoms, in particular *Melosira ranulata,* which is associated with eutrophication.

Most of the lake has very low (0.1-0.2 g/m^3) phytoplankton biomass and can be classified as ultra-oligotrophic on that basis. Biomass is homogeneously distributed with little inshore/offshore differentiation (Munawar and Munawar 1978) with the exception of Western Lake Superior has relatively high biomass concentrations. Nannoplankton comprise approximately 65 percent of the total phytoplankton, and smaller fractions (<10 µm) account for 32 percent of the biomass. Diatoms and phytoflagellates, especially cryptomonads and chrysomonads, dominate the lake-wide phytoplankton biomass. Dinoflagellates, green and blue-green algae contribute little to the total biomass.

No clear seasonal trends in biomass are apparent for most of the lake, although biomass is lowest when Lake Superior is unstratified (May-June, November-December) and highest from July to September when it is stratified. The overall cold temperature regime of Lake Superior is not conducive to rapid and sudden changes in the phytoplankton community (Munawar and Munawar 1978). Uniform vertical distribution of biomass appears to be typical of offshore conditions in most of the lake although at some offshore stations, phytoflagellate biomass is highest below the thermocline. In temperature-stratified nearshore conditions, there are peaks of diatom and phytoflagellate biomass near 10 m depth.

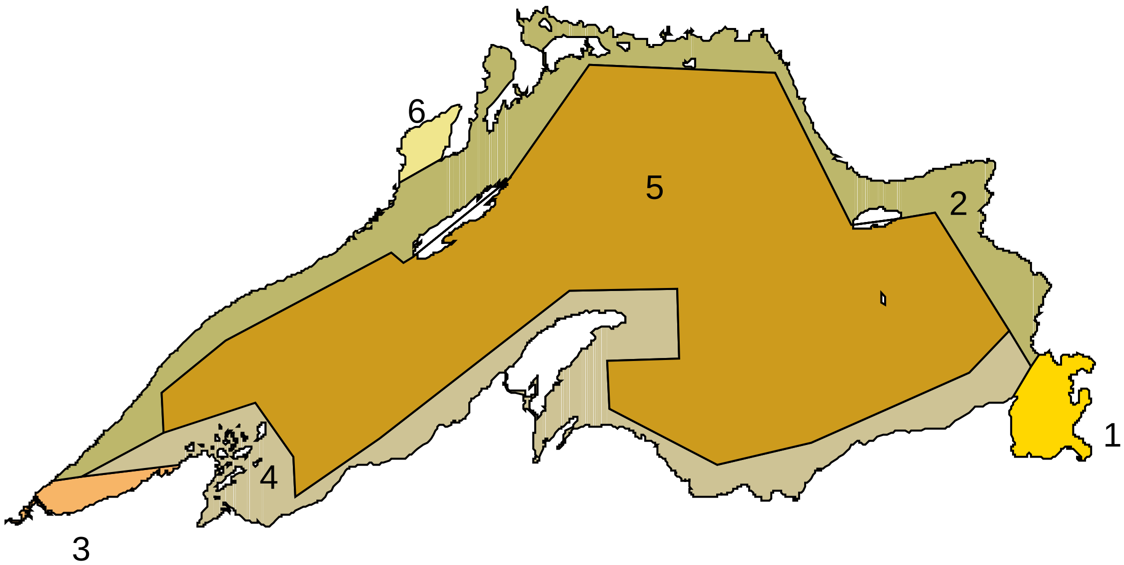


Figure 6-21. Phytoplankton zones of Lake Superior based on taxonomic data (1) Whitefish Bay, (2) Northern Nearshore, (3) Western End, (4) Southern Nearshore, (5) Main Lake, (6) Thunder Bay (Munawar and Munawar 1978)

6.1.3.2 Zooplankton

The zooplankton community of Lake Superior is spatially and temporally heterogenous. The lake-wide zooplankton is relatively homogenous in the spring, but during the early summer local clusters appear in many inshore areas, and by early fall the zooplankton community distribution is heterogenous. Zooplankton distribution and abundance is strongly associated with surface water temperature, and highest concentrations are found inshore, especially in the major embayments. Abundance is generally low in comparison with the lower Great lakes, and little variation in total numbers/m^3 is evident throughout the ice-free season. Seasonal concentrations peak at 45,000 individuals/m^3 in some inshore areas (Whitefish Bay) compared to only about 3000 individuals/ m^3 in the open lake (Watson and Wilson 1978).

The zooplankton community of Lake Superior is generally dominated by herbivorous filter feeders such as calanoid copepods and cladocera, although low numbers of raptorial cyclopoid copepods that feed on other zooplankton are also present. The zooplankton community of the open lake, and the lake-wide average, is dominated by large calanoid copepods such as *Diaptomus sicilis, Limnocalanus macrurus*, and *Senecella calanoides.*

These species appear to be present year-round, with a single reproductive pulse during the fall or early winter. Upwelling along the northern shore pushes warmer inshore water and its entrained zooplankton offshore, resulting in a unimodal pattern similar to those of the offshore areas. Major embayments and inshore areas along the southern and eastern shore have communities dominated by cladocera and smaller diaptomids. These communities tend to have a bimodal seasonal pattern, with a spring-summer peak dominated by calanoid nauplii and copepodites, and a fall peak of calanoid adults, cladocerans, and cyclopoids. Inshore species gradually extend into the offshore waters during the late summer and early fall and mix with the offshore assemblages. Homogenous lake-wide conditions return quickly with the turnover in late fall (Watson and Wilson 1978).

Zooplankton biomass distribution patterns in Lake Superior are strongly influenced by the differential heating of surface water, which is in turn influenced by lake morphometry, and movement of water masses (e.g. upwelling, thermal bars, currents). During the spring and early summer, biomass values are similar across the lake at approximately 4 mg/m^3. Inshore biomass peaks at approximately 60 mg/m^3 in August and September as cladoceran populations develop. Offshore and lake-wide biomass is primarily related to the growth and maturity of large calanoid copepods and peaks approximately one month later at 30 mg/m^3. Total biomass increases five-fold between May and September (Watson and Wilson 1978). The authors are unaware of additional recent research on zooplankton and will include these data, if such data exists, as this report is finalized.

Table 6-6 Dominant zooplanton species in Lake Superior (Watson and Wilson 1978)

Taxa	**Percent total numbers**	**Percent total biomass**
Calanoid copepods		
Diaptomus sicilis adults	11.0	20.0
Diaptomus ashlandi adults	2.5	2.5
Diaptomus spp. copepodites	18.0	17.0
Diaptomus spp. nauplii	44.0	7.0
Limnocalanus macrurus	5.5	32.0
Senecella calanoides	0.6	5.0
Calanoid Total	**81.6**	**83.5**
Cyclopoid copepods		
Cyclops bicuspidatus thomasi adults	1.0	1.0
Cyclops spp. copepodites	6.5	2.0
Cyclops spp. nauplii	5.0	0.5
Cyclopoid Total	**12.5**	**3.5**
Cladocerans		
Bosmina longirostris	1.2	0.1
Daphnia galeata mendotae	3.0	8.0
Holopedium gibberum	0.2	0.3
Cladoceran Total	**4.4**	**8.4**
Total	**98.5**	**95.4**

6.1.3.3 Benthic Communities

The benthic community of Lake Superior is dominated by the amphipod *Diporeia hoyi* (formerly known as *Pontoporeia affinis)*, followed by the oligocheates, especially the Enchytraeidae and the lumbriculid worm *Styoldrilus heringianus* (Cook 1975). Mollusks, primarily the sphaeriid pea clam *Pisidium conventus*, and insects, primarily the chironomid *Heterotrissocladius oliveri*, together accounted for less than 10 percent of the total biomass.

The benthic community of Lake Superior reflects the low diversity of habitat rather than impaired water quality. Sediment size, depth and therefore temperature are the major factors controlling the distribution of individual species. Sphaeriids and chironomids were associated with shallow water, on sandy and finer substrates respectively. *Diporeia* is most abundant in relatively shallow water (40-80m) compared to the mean depth of Lake Superior (160 m) (Freitag and others 1976; Dermott 1978). Tubificid *Rhyacodrilus* are associated with relatively shallow water depths and are replaced by *Phallodrilus* in deeper oligotrophic sites having sediments with lower organic matter. *Stylodrilus* and Sphaeriidae were negatively associated with the sediment zinc levels.

In deep water communities and much of western Lake Superior, mollusc and insect populations are extremely scarce, and in mid-lake locations with extremely low productivity, only the stenotherms *Diporeia* and *Stylodrilus* were present. The benthic community is richest in terms of abundance and diversity in the area south and east of Michipocoten Island, especially Whitefish Bay (Figure 22), due to lower mean depth (63 m) and higher algal populations. In contrast to the lake-wide mean, oligochaetes were dominant and Sphaeriidae comprised 12 percent of the biomass. Thunder Bay also has a relatively diverse benthic community where Sphaeriidae and Chironomini are more abundant than in the main lake. Benthic abundance and diversity was lowest in the Duluth area, and often restricted to *Diporeia*, despite abundant phytoplankton and pelagic heterotrophic bacteria populations (Munawar and Munawar 1978, Rao 1978).

6.1.3.4 Fish Communities

The native fish community of Lake Superior was and is still dominated by salmonines and coregonines, typical of post-glacial oligotrophic lakes in North America. Approximately 80 fish species belonging to 19 families occur in Lake Superior or its tributaries. Of these, twenty species are non-native that have been deliberately (e.g. chinook salmon, rainbow trout) or accidentally introduced (e.g. ruffe, sea lamprey, rainbow smelt) since the late 1800’s. Commercial and sport fishing pressure, introductions of non-native species, and changes in the physical environment (e.g. dams, mine tailings) have resulted in a fish community somewhat different and less stable than it was in the mid 1800’s (Hansen 1994, Paloheimo and Regier 1982).

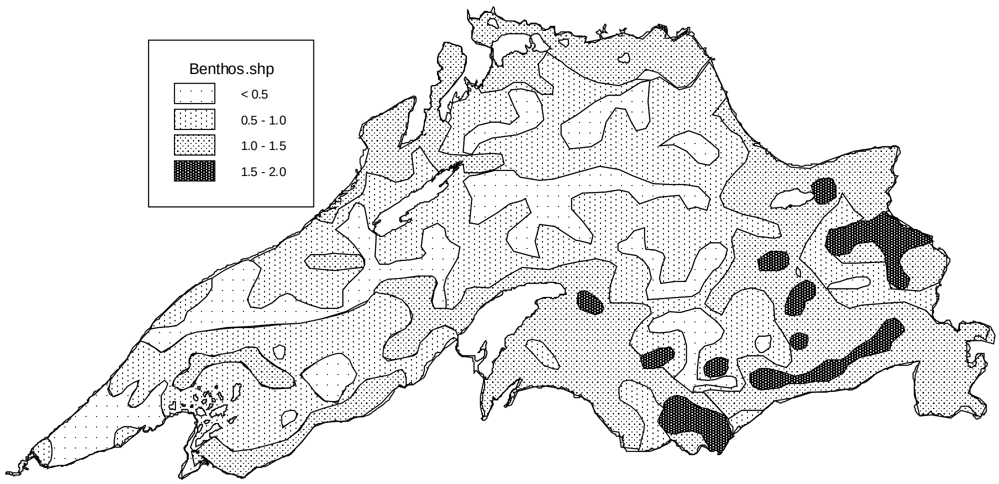


Figure 6-22. Benthic biomass diversity (Shannon's diversity index) (Dermott 1978)

Commercial fishing for lake whitefish (*Coregonus clupeaformis*) and lake trout (*Salvelinus namaycush*) began in the mid 1800's in Lake Superior to provide food for fur trading posts and other settlements (Waters 1987). By the late 1800's, increased human population and improved transportation resulted in intensified fishing effort, and improved boats and gear resulted in a more efficient harvest. Typically, the most accessible stock was fished heavily until the population declined, and then effort switched to another stock or species (Lawrie and Rahrer 1972, Regier and Loftus 1972). Records of depleted stocks date back as early as the 1870's and there was a general pattern of decline for many commercial species between the mid 1940's and early 1970's (Lawrie and Rahrer 1972). Declining populations of lake trout, burbot, whitefish and other species were further decimated during the 1940's and 1950's by sea lamprey (*Petromyzon marinus*) (Hansen 1994), which were first recorded from Lake Superior in 1938. During the time of highest sea lamprey abundance, up to 85 percent of fish not killed by sea lamprey exhibited sea lamprey wounds (Scott and Crossman 1973). Commercial fish yields from 1979 to 1983 in Lake Superior were significantly lower than historical yields (Table 6-7) mainly due to the collapse of the lake herring and lake trout, species that have not yet fully recovered. Angling has had less impact on fish populations, but contributed to the decline of some populations of lake trout and brook trout, especially in shallower waters. Since 1983, lake herring have produced larger year classes and most lake trout stocks have been restored. Control of commercial fishing has also contributed to the difference between early and more recent yields. Michigan closed lake trout fishing in 1962 and lake herring fishing in 1974. Although commercial fishing rights have been restored to Native American tribes, there are some Michigan waters of Lake Superior that have been closed even to tribal fishing.

Table 6-7 Mean annual fish yield ($kg \cdot ha^{-1} \cdot yr^{-1}$) and percent of total yield for Lake Superior contributed by different species or species groups (from Loftus and others 1987)

Species or Species Group	Early (1913-50)		Recent (1979-83)	
	Yield	**Percent**	**Yield**	**Percent**
Lake herring	0.651	66.4	0.139	36.6
Other ciscoes and chubs	0.018	1.8	0.041	10.8
Lake whitefish	0.048	4.9	0.080	21.1
Lake trout	0.240[a]	24.5	0.046	12.1
Rainbow smelt	0.000	0.0	0.041	10.8
Other species	0.021	2.1	0.028	7.4
Total	**0.980**		**0.380**	

[a]Based on the years 1920-45 only.

Historically, the fish community of the main lake was comprised of lake trout, coregonines (whitefishes and ciscoes), burbot, sticklebacks, sculpins, and suckers. Lake trout, and to a lesser extent burbot, were the dominant predators. Today, the predator mix has been expanded by the introduction of non-native salmonines, but lake trout remains the dominant predator. Lake trout made up about 93 percent of the predator biomass in western Lake Superior in the early 1990's (M. Ebner personal communication). Lake Superior contains three forms of lake trout referred to as leans, sicowets and humpers, but some discrete lean stocks are believed to have disappeared. The main forage of lean lake trout historically was lake herring. Lake herring was largely replaced by non-native rainbow smelt as forage in the1960's and 1970's, but re-emerged as major forage species in the 1980's following a decrease in rainbow smelt and abundance and production of several strong lake herring year classes (Selgegy and others 1994). Coregonines (mainly deepwater ciscoes), burbot, and sculpins are principal forage fish for siscowets.

Lean lake trout, steelhead, coho and chinook salmon are most abundant in nearshore waters less than 80 m depth. Brown trout and splake are less widely distributed than other naturalized salmonines. Coaster brook trout were formerly more abundant in nearshore areas but have been reduced by overfishing, competition with introduced species and destruction of spawning habitat in tributaries. Lake whitefish are less pelagic than other coregonines and are most abundant at depths of 20-50 m. Rainbow smelt are also abundant in nearshore waters.

The fish community of bays, harbors and estuaries is comprised mainly of perches, suckers, sculpins, and minnow species. Walleye is most abundant in mesotrophic waters less than 15 m depth, although they may be found deeper. Both walleye and lake sturgeon were formerly more abundant and exist mostly as suppressed localized populations. The recent introduction of exotic river ruffe, white bass and round gobies may have profound impacts on these warmwater communities. Approximately twenty species (e.g. catfishes and sunfishes) are restricted to the warmest weedy shallows of protected bays and estuaries. Tributaries are critical spawning and nursery habitat for many species, including walleye, sturgeon, burbot and salmonines. Various minnow species, native lamprey and the central mudminnow are generally confined to tributary waters.

Table 6-8 Principal fish species in the four main habitat zones of Lake Superior. "X" denotes presence of species during different life stages i.e. adult (A), juvenile (J), and/or spawning (S)

Principal Species	Adult Diet	Offshore (>80 m deep)			Nearshore (< 80 m deep)			Bays, Harbours, Estuaries			Tributaries		
		A	J	S	A	J	S	A	J	S	A	J	S
sea lamprey	fish				X							X	X
lake sturgeon	macroinvert.[1]				X	X		X	X				X
pink salmon	plankton	X			X							X	X
coho salmon	fish	X			X							X	X
chinook salmon	fish	X										X	X
rainbow trout	fish				X							X	X
brown trout	fish		X	X									
brook trout	macroinvert.				X	X		X	X				X
lake trout	fish	X	X	X	X	X	X						
lake whitefish	macroinvert.	X	X	X									
lake herring	plankton	X	X		X	X	X						
bloater	plankton	X	X	X									
kiyi	macroinvert.	X	X	X									
rainbow smelt	plankton				X			X	X	X			X
burbot	fish				X								X
ninespine stickleback	macroinvert.	X			X						X		
ruffe	macroinvert.				X			X	X	X			
Walleye	fish				X			X	X				X
slimy sculpin	macroinvert.	X									X		
Deepwater sculpin	macroinvert.	X											

[1] macroinvertebrates

Shoals and spawning areas for lake whitefish, lake herring, round whitefish and lake trout are shown in Figure 6-23.

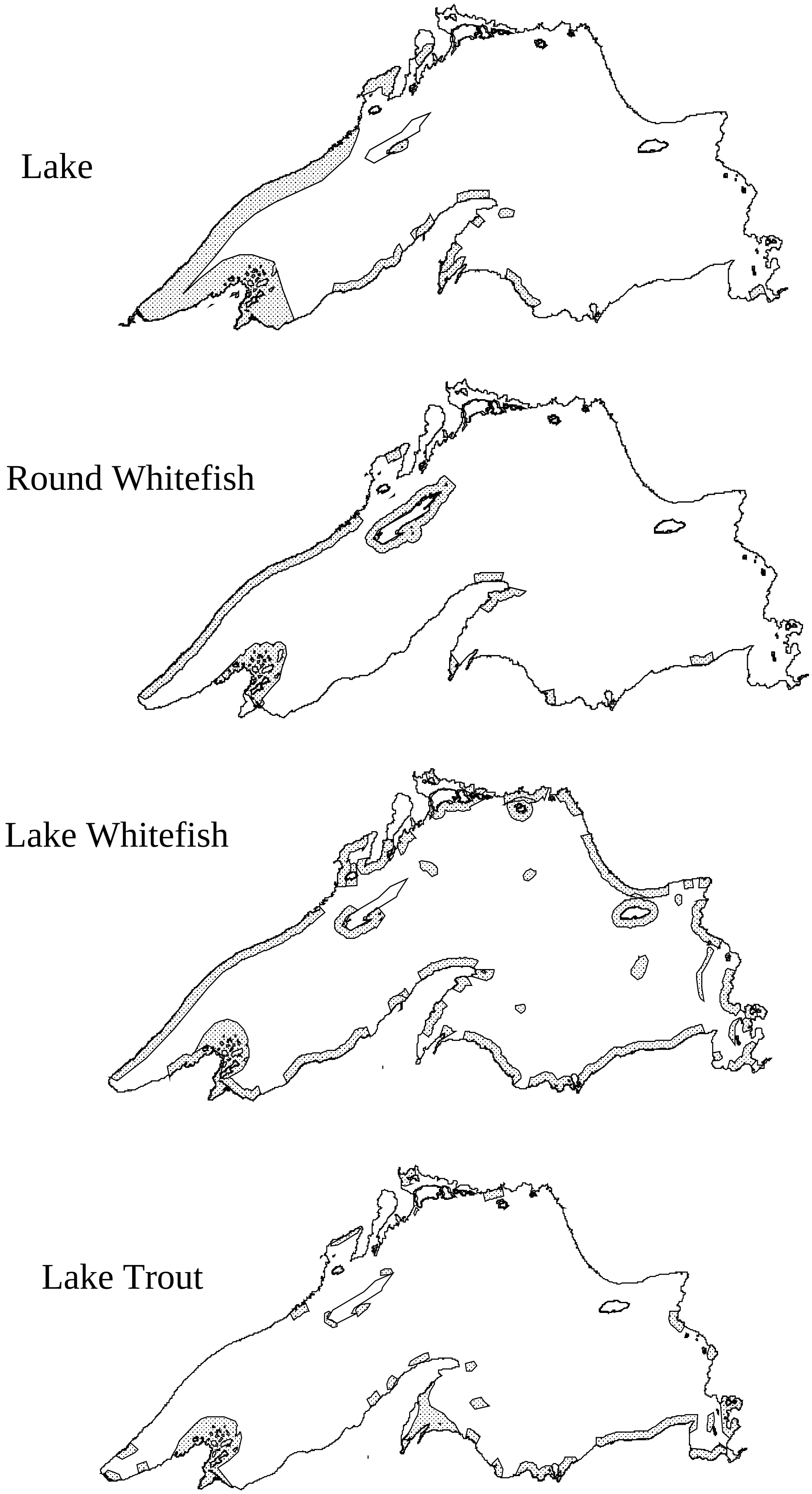


Figure 6-23. Spawning habitat for major fish species (from Goodier and others 1981)

6.1.4 The Terrestrial Environment

6.1.4.1 Ecological Land Classification

Ecological land classifications are "…useful and functional land units that differ significantly from one another in abiotic characteristics as well as in their related biotic components" (Albert 1995). They are based on relationships between vegetation and the physical environment, especially soils, landform, and climate.

The Lake Superior basin is subdivided into 37 land units following the U.S. Regional Landscape Classification (Albert 1995) and Ontario's Site Region classification (Hills 1959) (Figure 6-24). The U.S. system is based on climatic and physiographic features (bedrock features, glacial landforms, soils and vegetation) (Albert 1995), while Ontario's classification is based mainly on climatic factors (Hills 1959). Another Canadian land classification, Ecoregions of Ontario (Wickware and Rubec 1989), closely parallels Hills' system, at least within the basin.

Section VIII makes up most of the eastern part of the U.S. basin. Sandy soils, dunes and beach ridges associated with glacial lake plain are prevalent. Large expanses of peatland and swamp are associated with poorly-drained soils and flat topography. This Section is mainly forested, except the clay lake plains, which are used for pasture and forage crops. Prevailing winds off Lake Superior result in cooler summers and milder winters than Section IX. Lake effect snow and rain is common near Lake Superior (Albert 1995).

The middle part of the south shore (Section IX) consists of bedrock ridges and glacial moraines, lake beds, outwash channels and plains (Albert 1995). Soils are relatively nutrient-poor, acidic, and rocky. The Lake Superior Lake Plain (IX.8) extends for approximately 200 miles along the lakeshore from Duluth / Superior to the Keweenaw Peninsula. Soils are lacustrine clays and clayey till. Most of the Keweenaw Peninsula is bedrock knob and sandy till. Climate is strongly continental with only moderate lake influence.

Section X constitutes most of the Minnesota basin. It consists mainly of morainal landforms with low bedrock knobs. Forest composition shifts from northern hardwoods in Section IX to more boreal pines and hardwoods in Section X. Climate is slightly drier and cooler than IX, but winter precipitation is less, contributing to spring fires.

Site Region 4W (Pigeon River), marks the transition between Great Lakes/ St. Lawrence forest and boreal forest. Along Lake Superior, the topography is rugged with shallow soils. West of Thunder Bay, deep, clayey, glacial lacustrine soils are found.

Site Region 3W (Lake Nipigon) and Site Region 3E (Lake Abitibi) have typically boreal forests dominated by black spruce, jack pine, trembling aspen, and white birch. Topography is rugged with shallow morainal soils. Near Lake Superior, deep glacial valleys are filled with sandy outwash and varved lacustrine clays.

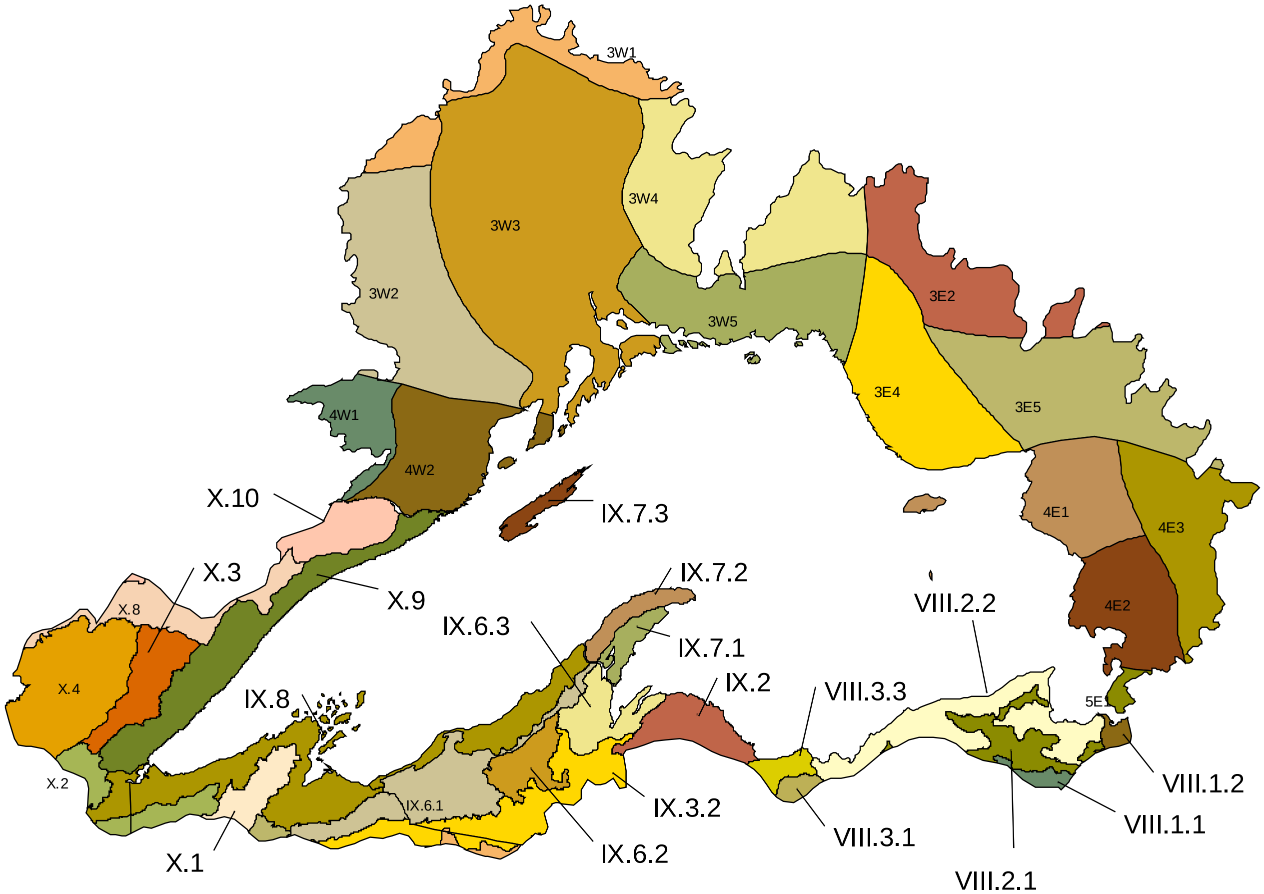


Figure 6-24. Ecological land classification of the Lake Superior basin (Hills 1969 and Albert 1995)

Table 6-9 Regional landscape ecosystems of Michigan, Minnesota, and Wisconsin (Albert 1995)

SECTION/ SUBSECTION	SUB-SUBSECTION	
Section VIII. Northern Lacustrine-Influenced Upper MI and WI		late Wisconsinan-age glaciated landscape; northern hardwoods forest, jack pine barrens, white pine-red pine forest, conifer swamp, bog.
VIII.1. Niagaran Escarpment and Lake Plain	VIII.1.1. St. Ignace	Limestone bedrock and sand lake plain; conifer-dominated upland and wetland forests, northern hardwoods, fens, coastal emergent marshes, alvar
	VIII.1.2. Rudyard	Clay lake plain; conifer and hardwood-conifer-dominated uplands and wetlands; coastal marshes.
VIII.2. Luce	VIII.2.1. Seney Sand Lake Plain	Very poorly or excessively drained sand lake plain, transverse dune, outwash; shallow, paludified peatlands (many patterned), jack pine barrens, hardwood-conifer and conifer swamp.
	VIII.2.2. Grand Marais Sandy End Moraine and Outwash	Sandy end-moraine ridges and outwash aprons, Lake Superior shoreline features, transverse dunes, sand spits; white pine-red pine forest, jack pine barrens, red pine forest, northern hardwood forest, and patterned peatlands.
VIII.3. Dickinson	VIII.3.1. Northern Lake Michigan (Hermanville) Till Plain	Sandy and loamy ground moraine, drumlin fields; northern hardwood forest (with large amounts of hemlock and northern white-cedar), northern white-cedar swamp, hardwood-conifer swamp.
	VIII.3.3. Deerton	Sandstone bedrock and high sandy ridges; northern hardwood forest, conifer swamp.

Table 6-9 Regional landscape ecosystems of Michigan, Minnesota, and Wisconsin (Albert 1995)

Section IX. Northern Continental MI, WI, and MN		Precambrian Shield bedrock, late Wisconsinan-age glaciated landscape; northern hardwoods forest, white pine / red pine forest, jack pine barrens, hardwood-conifer and conifer swamp, bog.
IX.2. Michigamme Highland	Precambrian granitic and sandstone bedrock knobs, rocky ground moraine, bedrock lakes, localized outwash plains; northern hardwood forest, white pine-red pine-red oak on bedrock, balds, localized jack pine barrens.	
IX.3. Upper WI/MI Moraines	IX.3.2. Winegar Moraine	Coarse-textured ice-stagnation moraines (with numerous kettle lakes); northern hardwood forest, bog.
	IX.3.4. Chippewa-Green Bay Lobes	Stagnation moraine with sandy soils, kettle lakes; northern hardwood forest and bogs
IX.5. Lac Veaux Desert Outwash Plain	(Northern Highland Lakes Barrens); pitted outwash plain, kettle lakes; jack pine barrens, white pine-red pine forest, conifer swamp, bog.	
IX.6. Bergland	IX.6.1. Gogebic-Penokee Iron Range	Bedrock and large moraine ridges; northern hardwoods, white pine-red pine forest on thin soils.
	IX.6.2. Ewen	Highly dissected lake plain; northern hardwood forest, white pine forest, spruce-fir forest
	IX.6.3. Baraga	Broad ridges of coarse-textured rocky till; northern hardwood forest, few wetlands.
IX.7. Keweenaw	IX.7.1. Gay	Coarse-textured broad ridges and swamps; sandy till plain; rocky, sandy ground moraine; northern hardwood forest, hardwood-conifer and conifer swamp, bog.
	IX.7.2. Calumet	Basalt and conglomerate "trap rock"; bedrock knobs and shoreline; northern hardwood forest, balds, white pine forest, white pine-red pine-red oak on bedrock, spruce-fir forest, bog.
	IX.7.3. Isle Royale	Island of volcanic bedrock ridges and wetlands; hardwood-conifer-dominated upland and wetland vegetation.
IX.8. Lake Superior Lake Plain	Level clay lake plain and water-reworked moraine of clayey till; spruce-fir forest, white pine-hemlock forest.	
Section X. Northern MN		Precambrian Shield bedrock, late Wisconsinan-age glaciated landscape; upland conifer forests, extensive paludified peatlands and conifer swamps.
X.1. Bayfield Barrens	Ice-stagnation topography with kettle lakes and outwash; jack pine barrens.	

Table 6-9 Regional landscape ecosystems of Michigan, Minnesota, and Wisconsin (Albert 1995)

X.2. Mille Lacs Uplands	Rocky, loamy ground moraine and end moraines; white pine-sugar maple, white pine-red pine, and aspen-birch forests, oak forests at south and west edge of subsection, conifer swamps.
X.4. Tamarack Lowlands	(Upham lake plain and Aurora till plain); loamy glacial lake plain and ground moraine; conifer swamp, bog, aspen-birch forest.
X.8. Nashwauk Uplands	Steep to gently sloping ground moraine with calcareous, loamy soils and sandy outwash plains; aspen-birch forest, mixed hardwood-pine forest, jack pine barrens; conifer bog, conifer swamp, and muskeg.
X.9. North Shore (Lake Superior) Highlands	End moraine, ground moraine, and clay lake plain; white pine-red pine and aspen-birch forests on uplands, localized sugar maple on uplands near the Lake Superior shoreline.
X.10. Border Lakes	Glacially scoured granitic and basaltic bedrock knobs and lakes; spruce-fir forest, jack pine forest, white pine-red pine forest.

6.1.4.2 Vegetation

Approximately 10,688,000 ha or 88 percent of the Lake Superior basin (excluding Lake Nipigon and Lake Superior itself) has been classed as forest, either conifer, hardwood or a mixture using Landsat TM spectroanalysis (Figure 6-25 and 6-26). An additional 1.3 percent of the basin is comprised by early seral hardwoods and only 4.5 percent is classed as grass or brush. Most of the smaller non-forested communities, including the majority that are rare, are not identified at this level of resolution however.

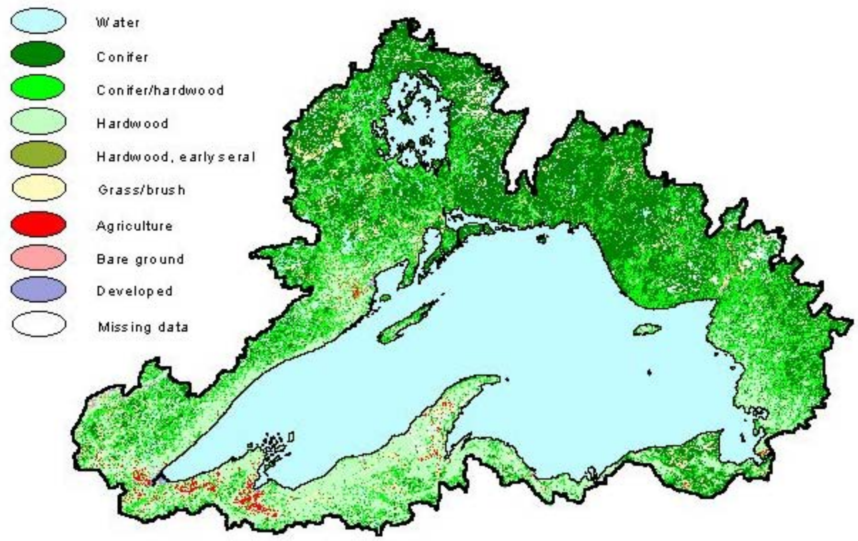


Figure 6-25. Current land cover classes of the Lake Superior basin (derived from Landsat Thematic Mapper (TM) remote sensing)

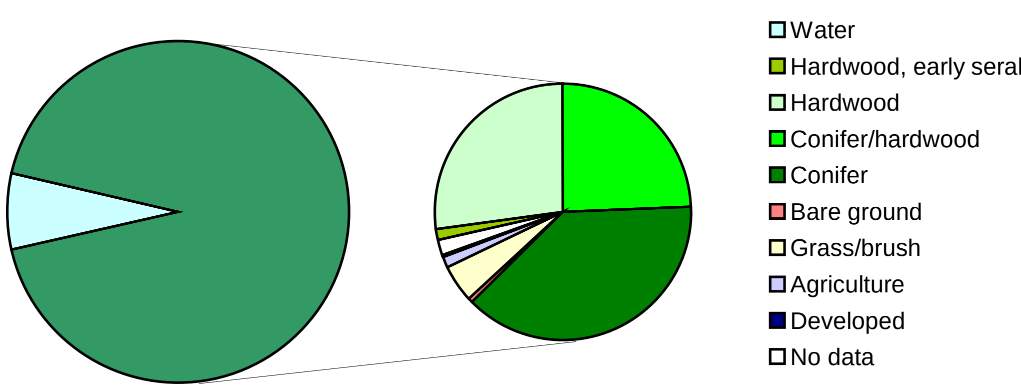


Figure 6-26. Proportion of Lake Superior basin (excluding the lake itself) in various land cover classes (1999)

Old Growth Forest

"Old growth" has been variously defined and applied, but typically is used to describe forest ecosystems with old trees and their associated plants, animals, and ecological processes. In the Lake Superior basin, old growth usually refers to forests that are dominated by long-lived species including red and white pine, oaks, northern hardwood species, and lowland conifers. The age at which this occurs depends on species composition, site variables, and stand conditions, but is approximately at 120 years for long-lived species (Frelich and Lorimer 1991, Heinselman 1973). Forests dominated by short-lived species (those that normally live from 60 to 100 years) such as trembling aspen, paper birch, balsam fir and jack pine are relatively old at age 80 and are have been referred to as “old-seral” forest (Frelich 1995). Old growth usually refers to primary forests i.e., those that were established naturally and show little or no evidence of human disturbance, but may also be secondary forest (those that have experienced human-caused fires or logging).

The age structure of presettlement forests was determined largely by natural disturbance regimes. In the boreal forest, stand-regenerating fires usually occurred every 50 to 200 years (Heinselman 1981), so that old growth was a temporary phenomenon that was usually only attained by oak, and red and white pine stands (Frelich 1995). In contrast, fires were rare in the Great Lake-St. Lawrence Region / Laurentian Mixed Forest Province, and catastrophic windstorms and tornadoes occurred at greater than 1000-year intervals. Many of these forests were multigenerational and old growth conditions could last centuries.

Approximately 5 to 8 percent of the Lake States forest is presently old-growth (including old seral forest). Only about 1 percent of the presettlement primary forest remains in the Lake States, of which more than 90 percent is located outside the Superior basin. Nearly all the primary forest within the American side of the basin is retained in large wilderness areas and parks. Very little red and white pine, river bottom northern hardwood, and oak-hickory forests remain. In contrast, it is estimated that 68 percent of presettlement forests in the Lake States were old growth. The proportion of old growth varied among presettlement forest types, with 20 percent of jack pine forests, 45-55 percent of red-white pine, spruce-fir-birch, swamp conifer, oak-hickory, river bottom forests, 89 percent of northern hardwood forests (Frelich 1995).

The only large, primary upland forests in the American side of the Lakes Superior basin are those of the Porcupine Mountains Wilderness State Park (14,164 ha) and the Northshore Highlands (600 ha within the Boundary Waters Canoe Area Wilderness). Porcupine Mountains Wilderness State Park and Pictured Rocks (400 ha) contain most of the protected northern hardwoods in the basin. Isle Royale National Park has 38 percent of the Lake States' protected old growth spruce-fir, but has been logged. Over 90 percent of the forest in the Porcupine Mountains WSP are older than 120 years, compared to approximately only 10 percent in adjacent commercial forests (Frelich 1995). The Porcupine Mountains is largest old growth northern hardwood forest in North America and is closest to presettlement condition of any upland forest remnant in the Great Lakes region. Minnesota has 13 old growth sites totaling 1600 to 2000 (Kershner 1999). The private Huron Mountain Reserve has 2600 ha of old growth (Kersner 1999).

Most of the Canadian side of the basin is boreal and predominately seral forest. A summary report, which defines the onset and duration of old growth conditions is being prepared by the OMNR and will be available later in the year. A Conservation Strategy for Old Growth Forest Ecosystems in Ontario was developed in 1994 by the MNR (Policy Advisory Committee 1994). Most of the inventory and study of old growth forests on the Canadian Side of the basin has focused on longer-lived red and white pine. Fire suppression has resulted in older ages for some stands, but widespread logging has removed other old growth stands. There are 123 old growth (>120 years) red and white pine stands identified on the Canadian side of the basin covering a total of 3819 ha. Most of these stands are in the southeast or northwest portion of the basin (Figure 6-27). Distribution and abundance of old growth for other species are not yet available.

6.1.4.3. Disturbance

Two major disturbance regimes naturally occurred in the forests of the Lake Superior basin. In the hemlock and hardwood forests in the U.S. side of the basin, fire was relatively rare and the major disturbances were heavy or catastrophic windstorms and tornadoes that occurred at greater than 1000-year intervals (Frelich 1995). Catastrophic disturbances were relatively small (~100 ha) with an approximate maximum size of 4000 ha (Canham and Loucks 1984). Windstorms could remove 10 to 50 percent of the forest canopy in a given stand every 100 to 300 years (Frelich and Lorimer 1991). In contrast, fire is the most important landscape-level disturbance in the boreal forests and pine forest of the Great Lakes/St. Lawrence Region. Fire is essential to the regeneration dynamics of most boreal forest species, particularly early successional species such as jack pine. A site's long-term cumulative fire history plays an important role in determining present-day vegetation, since some areas are burned more frequently than others (Heinselman 1973). Fire in lowland conifer for example is less frequent than xeric sites.

The fire return interval or fire cycle is the average period of time between stand replacing fires in the same stands, assuming all stands in the forest burn once during the interval. The natural fire cycle for Quetico Provincial Park is 78 years (Woods and Day 1997) and approximately 122 years for the Boundary Water Canoe Area Wilderness (BWCAW) (Heinselman 1996). Based on a fire cycle of 70 years, the average annual burn fraction (i.e., the proportion of the total forest that would burn each year on average), was 1.5 percent for boreal forests in Ontario (Ward and Tithecott 1993). Since 1920, fire has burned approximately 1,212,135 ha or 16 percent of Canadian portion of the basin (on average 0.2 percent per year), most of which is predominately boreal (Figures 6-28 and 6-29).

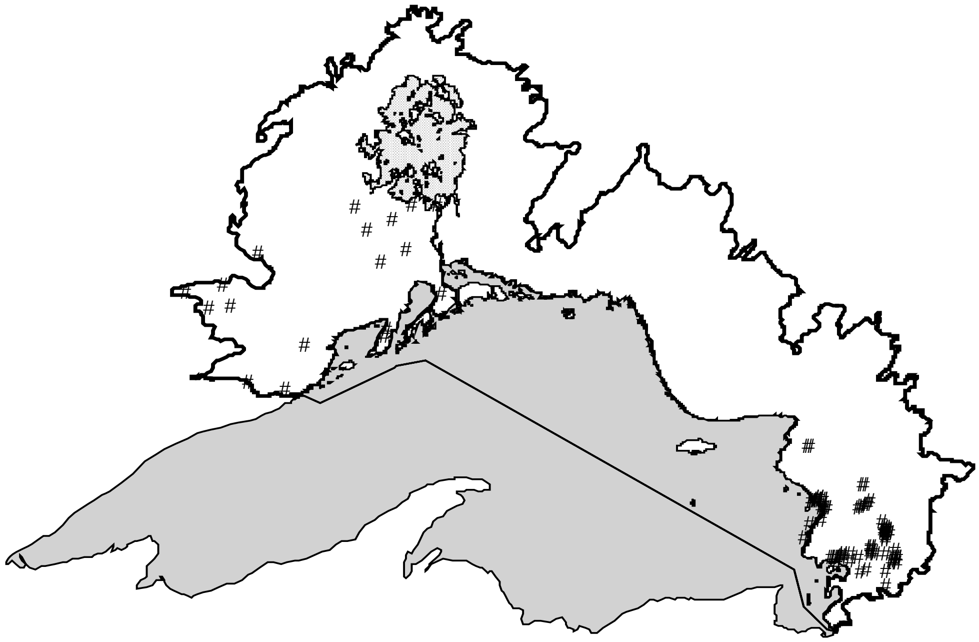


Figure 6.27. Old growth red and white pine stands in the Ontario Lake Superior Basin (OMNR data)

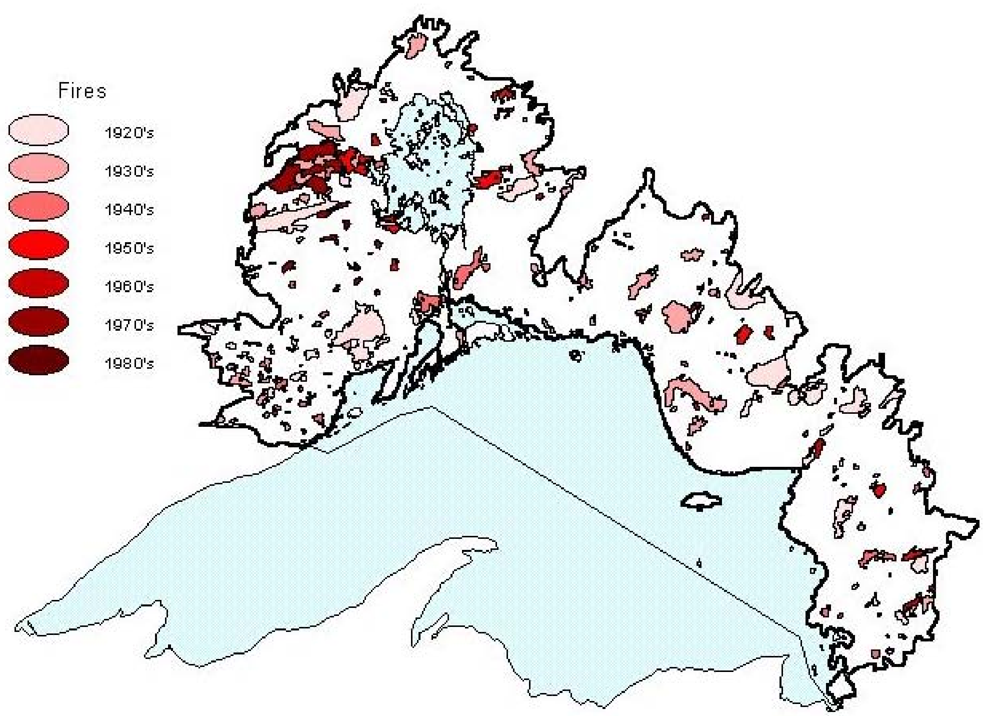


Figure 6-28. Occurrence of fire in the Canadian portion of the Lake Superior basin 1920-1990

The areal extent of fires in each decade has decreased steadily within the basin as a result of a more aggressive policy of fire suppression, combined with improved detection and fire-fighting methods. With the exception of some islands, most of the Canadian Lake Superior basin is within the intensive fire management zone of the OMNR, which means that fires are actively suppressed. Despite this, a very large fire burned approximately 111,000 ha west of Lake Nipigon in the 1970s. With that exception, there are fewer large fires currently than historically would have occurred.

The main source of ignition historically was probably lightning. Lightning is more or less random, but ground strikes tend to be more frequent on high ridges (Heinselman 1996) and lightning-induced fire is often associated with bedrock. First Nations would have been another possible source of fire, but native peoples may not have been a major cause of forest fires in northeastern North America (Russell 1983). Habitat manipulation for large game would have been unlikely, since caribou was historically the dominant ungulate and prefer mature forests. Habitat manipulation for food plants may have occurred since it has been reported that the Ojibway regularly burned ridges in the BWCA to encourage blueberry production (Heinselman 1996).

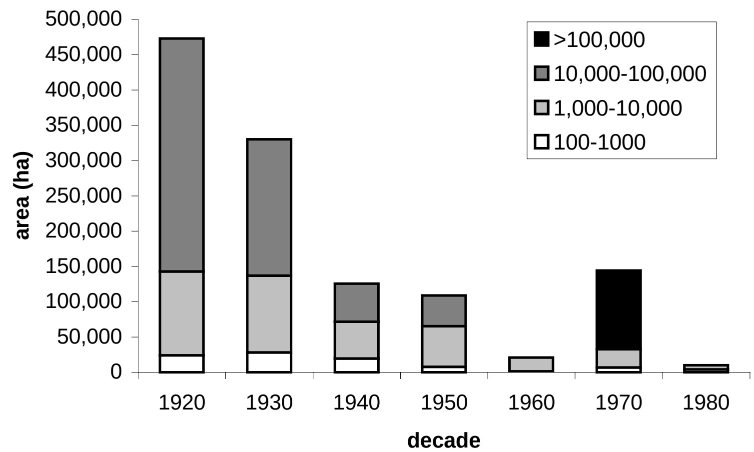


Figure 6-29. Areal extent of fires in the Canadian portion of the Lake Superior basin by fire size class (ha) and decade

Spruce budworm (*Choristoneura fumiferana*) is the most important forest pest in the Lake Superior basin in terms of total area infested, length and frequency of outbreaks, as well as volume and numbers of trees killed (Candau and others 1998). It attacks primarily balsam fir, followed by white spruce, and to a lesser extent black spruce. Affected trees will die if exposed to 3-5 years of consecutive years of defoliation, and almost all the trees in dense, mature balsam fir stands can be killed during uncontrolled outbreaks. Spruce budworm outbreaks are very large-scale phenomena and usually consist of many infestations that occur in different localities within the basin at about the same time.

Outbreaks of high budworm densities and heavy defoliation occur every 20 to 100 years and usually last 5 to 15 years (Blais 1983). During the 18^{th} and 19^{th} centuries, outbreaks have occurred in the Lake Nipigon region at approximately 70-year intervals (Blais 1983, 1985). Lake Nipigon is one of three "hot spots" in Ontario for spruce budworm outbreaks with about 6,600,000 ha that has been frequently defoliated, i.e., in >1/3 of the years from 1941 to 1998 (Candau and others 1998). Extensive defoliation occurred in this "hot spot" in 1948, 1985, and 1992, with smaller peaks in other years, with an average interval of 38 years between outbreaks. Widespread mortality of balsam fir and white spruce results in a loss of valuable wood, increased risk of fire and windthrow, with associated public safety risks and degraded aesthetics.

Windthrow relatively common in boreal forests, and is the other major natural disturbance in the Lake Superior basin. Shallow-rooting species such as white spruce and white pine are particularly vulnerable (Foster 1988), as are forests heavily affected by spruce budworm. Wide-scale catastrophic windstorms occur infrequently in the basin, but may have significant impacts. For example, a violent windstorm resulted in approximately 2300 ha of moderate to severe blowdown in 1997. Mineral soil exposed following windthrow may be important in boreal forest regeneration dynamics (Jonsson and Dynesius 1993).

6.1.4.4 Succession

Succession in the boreal forest and oak or pine forests farther south in the basin are dependent on disturbance by fire. These forests are typically dominated by pioneer species such as jack pine, white birch and trembling that have low to moderate shade tolerance. The successional species was generally set back every 50 to 100 years by fire in these forests and every 150 to 200 years in red-white pine forests and oak forests (Heinselman 1981). Many of these forests were one-generational in that many of the first trees to invade after the stand-originating fire lived until the next catastrophic fire (Frelich 1995). As long as intolerant hardwoods and jack pine form vigorous, fully-stocked stands, they restrict the development of shade tolerant species. However, as canopy openings are created by the death of the short-lived hardwood component, more shade tolerant species such as white spruce and balsam fir are able to succeed. In the continued absence of fire, shade-tolerant species, particularly balsam fir will often persist on mesotrophic sites. On more oligotrophic sites in the boreal forest, black spruce is often the dominant species.

Succession in the hemlock and hardwood forests of the southern portion of the basin was historically characterized by gap dynamics. In between infrequent disturbance events, these multi-generational forests were dominated by shade-tolerant species such as sugar maple, beech and hemlock that can reproduce without large canopy openings. Other mid-tolerant species such as yellow birch and green ash and basswood could reproduce in gaps caused by the death of canopy trees (Frelich 1995).

6.1.4.5 Wildlife

The Lake Superior basin represents a north-south and, to a lesser extent, an east-west transition zone for wildlife. Although many of the 59 species of mammals native to the Lake Superior basin have wide-ranging distributions, approximately 1/4 are predominately boreal and 1/5 are species primarily from more southerly deciduous forests (Burt 1975; Dobbyn 1994). Most of the remaining species have predominately eastern (e.g. rock vole) or western (e.g. thirteen-lined ground squirrel) affinities. Lake Superior itself represents a barrier to dispersal, as does the change in forest composition and climate. With the potential exception of the kiyi (*Coregonus kiyi*) and the blackfin cisco (*C. nigripinnis*), no vertebrate species are endemic to the Lake Superior basin. Introduced species include the European hare, Norway rat, and house mouse.

The fauna of the Lake Superior basin has changed since the last Wisconsin glaciation, particularly so in the past several hundred years as a result of over-hunting and habitat change, notably the loss of unfragmented and older successional forests. Large predators and ungulates have been most affected. Bison and wapiti have been extirpated from the basin; woodland caribou, wolverine, cougar, and grey wolf have been greatly reduced in abundance and distribution, particularly in the southern portion of the basin. A few species such as white-tailed deer and the coyote, have benefited from habitat change and expanded their ranges and numbers (Hazard 1982; Frelich and Lorimer 1985). Many game species, predators and furbearers such as the moose, black bear, river otter, bobcat and beaver were nearly extirpated near the turn of the century but have recovered to some degree, although not to presettlement levels (Burt 1975).

The avifauna of the Lake Superior basin also reflects this north-south transition. In the northern portion of the basin, boreal species such as the great gray owl, spruce grouse and three-toed woodpeckers are most common. Farther south, species typical of the Great Lakes/St. Lawrence and/or deciduous forests are found, e.g. rose-breasted grosbeak, scarlet tanager, and red-headed woodpecker. Widespread species such as the American crow, black-capped chickadee, and red-tailed hawk are found throughout the basin. A few species with western affinities (e.g. yellow-headed blackbird, are also found locally. Approximately 130 to 150 species, including most waterfowl, shorebirds and passerines, breed within the Lake Superior basin during the summer, but overwinter elsewhere (Cadman and others 1987). A smaller number of species (<30) are permanent residents, for example most owls, woodpeckers and grouse. A few (<10) species, such as the snowy owl, northern shrike and redpolls, breed further north and are only winter residents in the basin. Although not on a major flyway, relatively large numbers of migrants pass through on the eastern and western sides of Lake Superior. Introduced species include the rock dove, house sparrow, starling, and Hungarian partridge among others.

The herpetofauna of the basin is limited to approximately 31 species, primarily due to the northern climate. Reptiles include at least eight species of snake, most of them south of Lake Superior, and five species of turtles, including Blanding's and wood turtles which are declining throughout much of their North American range. The spring peeper, American toad, northern leopard and wood frogs are the most abundant of 11 anuran species, and the eastern newt, eastern redback and blue-spotted salamanders are the most widespread of the seven species of caudates (Cook 1984; Conant and Collins 1991).

6.1.5 Islands

Lake Superior hosts some extensive archipelagos, notably the island chain along the Black Bay Peninsula and the Apostle Islands. There are approximately 1,763 islands in Lake Superior, most of which are in Canadian waters (Figure 6-30).

Lake Superior islands represent over 1672 km^2 and 2265 km of shoreline. They range from small barren rock outcrops to Isle Royale, which is 71 km in length (Figure 6-31). Most (71%) of islands are less than one hectare, but they represent only 0.2% of the total island area. The three largest islands, Isle Royale, St. Ignace I. and Michipicoten I. represent 62% of the total island area.

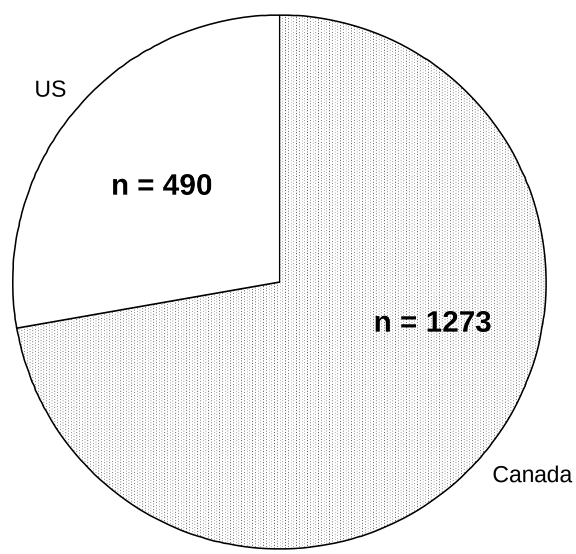


Figure 6-30. Lake Superior islands (compiled from U.S. EPA 1994 and Environment Canada 1993)

Islands habitats contribute significantly to the biodiversity of the Lake Superior basin and provide important habitat distinct from most mainland sites. In 1995 a joint U.S.-Canada workshop to assess the State of the Great Lakes Islands, it was determined that the natural biological diversity of the islands of the Great Lakes is of global significance (Vigmostad 1998). At the 1996 State of the Lake Ecosystem Conference, islands were also specifically identified as one of seven special ecological community types recognized within the Lake Superior basin (Reid and Holland 1997).

The cold, oligotrophic nature of Lake Superior and the harsh microclimates of exposed shorelines on many islands have created conditions suitable for scattered populations of plants normally only found in arctic or alpine regions. These species were present immediately after the last Wisconsin glaciation and have been able to persist because of these climatic refugia. Many of these plants, known has "arctic-alpine disjuncts", are well-represented in Lake Superior.

Island ecosystems are greatly influenced by their isolation from mainland communities. Their isolation tends to simplify wildlife communities and provide protection from predators (Reid and Holland 1997). Islands often serve as "living laboratories" where studies of the impact of herbivores, predator-prey relationships, evolution and extinction, population dynamics, animal cycles, dispersal, and rapid population growth can be conducted.

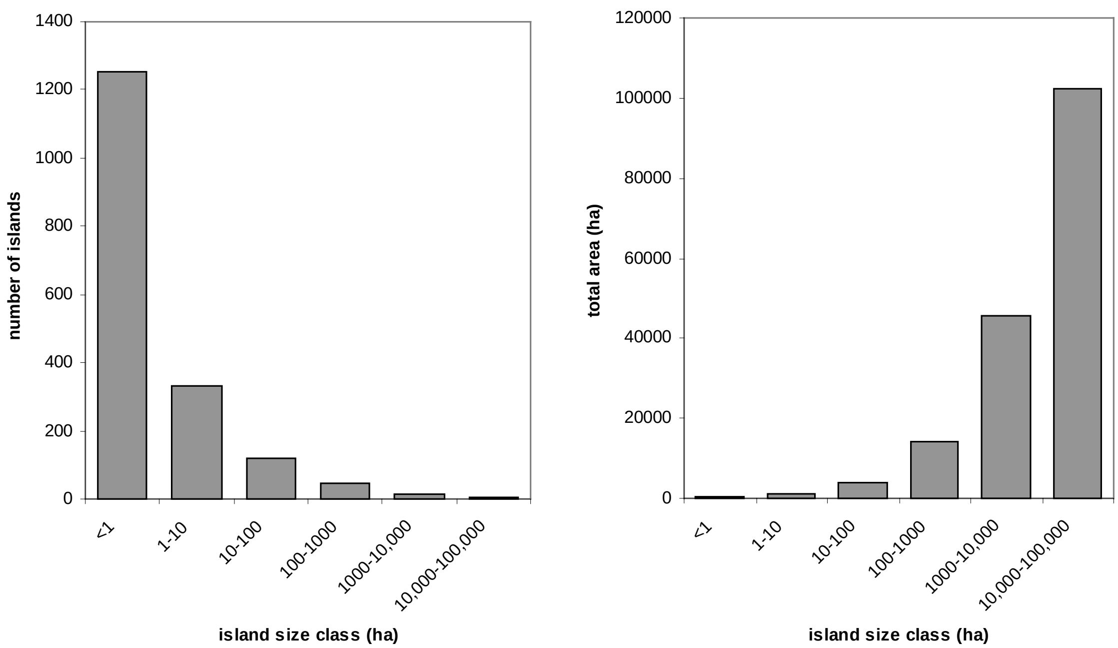


Figure 6-31. Lake Superior islands size distribution in termsof number of islands and total area
(compiled from U.S. EPA 1994 and Environment Canada 1993)

Moose commonly calve on small islands and woodland caribou persist (naturally or by reintroduction) on some offshore islands as well due to the absence of wolves. Many of the Lake Superior's islands provide primary nesting sites for ring-billed and herring gulls, double-crested cormorants, and great blue herons (Blokpoel and Scarf 1991). The isolation of island habitats that affords benefits to many colonial and ground nesting birds by significantly limiting egg predation by animals such as foxes. Islands are also particularly important to migratory neotropical-nearctic species (Vigmostad 1998). Islands often provide "stop-over" refuge for birds flying over open water at night or form natural extensions to mainlands that follow critical migratory flight corridors.

Islands are extremely important to birds and other wildlife and many suggest that this use is becoming intensified as mainland habitats have become increasingly fragmented. Islands are by their nature subject to human curiosity and regularly attract human visitation to their shores.

Human intrusions can range from recreational visitation by boaters to larger scale developments that involve physical infrastructure developments.

Fortunately, many of the islands in Lake Superior enjoy protected area status. Lake Superior islands may be particularly suited to serve as biosphere reserves especially in terms of sentinels to detect the long-range transport of toxic materials (Vigmostad 1998). They are under stress, however from increased recreational use particularly sea-kayaking and boating, and changing lake levels. Due to their isolation, they are also sensitive, since if island populations are extirpated, there may be limited potential for recolonization from the mainland.

Isle Royale

Isle Royale is the largest island in Lake Superior (555 km^2) and is located approximately 22 km from the nearest mainland. Climax spruce-fir and yellow birch-sugar maples are the dominant forest cover. Isle Royale is well-known for its long-term studies of predator-prey relationships involving wolves and moose. Caribou were historically present, but white-tailed deer, black bear, raccoons and porcupines are notably absent. Isle Royale is perhaps best known of the Lake Superior Islands because of its U.S. National Park and International Biosphere Reserve designation. It is the only island based national park in the United States and is a federally designated wilderness area (Vigmostad 1996).

Apostle Islands

The 23 Apostle Islands cover over 219 km^2 and comprise approximately 291 kilometers of shoreline. A major area of Wisconsin's Lake Superior shoreline lies within the Apostle Islands National Lakeshore, which is managed by the U.S. National Park Service. The Apostle Islands include many important habitats that are protected through its status as a national park. The Apostle Islands are comprised of very old pre-Cambrian sandstone, the remnants of an old braided river channel river channel that created a unique archipelago with almost grid-like spacing. These islands are largely comprised of hemlock forests with some pine being found on sand spits. Outer Island has one of the largest remaining virgin hemlock hardwood forests in the Great Lakes region (Vigmostad 1998).

Grand Island

Grand Island lies just offshore in Grand Bay, Lake Superior, near Munising, Michigan, west of the Picture Rocks National Lakeshore. This 55 km^2 island is managed by the Hiawatha National Forest as a National Recreation Area, and features sandstone cliffs on the northwest, north and western shorelines.

Outstanding features of this island include a tombolo connecting two parts of the island and an expansive marsh on Murray Bay. The marsh includes wet meadow, shrub swamp and poor conifer swamp, features a diverse and unusual array of plants. Upland conifers dominate the northern ridges. The upland areas feature some rare plants, habitat for peregrine falcons, and a small, forested Research Natural Area. This is the only large island in Michigan's portion of Lake Superior that consists of sandstone bedrock (adjacent small islands are also sandstone), and second only to Isle Royale in size in Michigan's portion of Lake Superior. Peregrine falcons last nested on the island in 1906, but were reintroduced to the island in 1992.

Grand Island has very high biodiversity significance, primarily because of the excellent quality marsh. The Michigan Natural Areas Council has worked on developing a vegetation monitoring plan for the island in response to impact concerns that may arise from recreational uses.

Slate Islands

The Slates Islands are an archipelago of 58 islands that are approximately 13 km from the mainland shoreline near Terrace Bay on the north shore of Lake Superior. They range in size from barely exposed rocks to large islands such as Mortimer I. (8 km^2) and Patterson I. (22 km^2). The Slate Islands have exceptionally interesting and significant geology including shatter cones. They are comprised of an array of metamorphic rocks indicative of an ancient volcanic cone or perhaps thought to be the remnants of a crater from a meterorite impact (Snider 1989). However, some of the Slate Islands are relatively young having emerged approximately 3,000 years ago slowly rebounding from the weight of glaciers.

On the Canadian side, the Slate Islands provide an excellent example of how isolation from the mainland has affected wildlife communities. Many large mammals such as moose, deer or wolves have not made the crossing to the Slate Islands (in 1997 two wolves are believed to have reached the island across the ice, but have not persisted). This has enabled extremely high densities of woodland caribou to persist; they have the largest woodland caribou population (200-400 animals) in the Lake Superior basin south of their continuous distribution. The Slate Is. are also notable for populations of arctic-alpine plants and devil's club (*Oploplanux horridus*) as western disjunct also found on Porphyry Island and Isle Royale. Herring gulls nest on at least seven locations, including the Leadman Is.

The Slate Islands and surrounding waters within 400 m of shore are protected in the Slate Islands Provincial Park. There is also Canadian Coast Guard lighthouse and outbuilding on federal land on the south shore of Paterson Island.

Black Bay Peninsula Archipelago

Over 480 islands form an archipelago along the outer edge of the Black Bay Peninsula and Nipigon Bay along the north shore of Superior. They include wave-washed rocks to a number of large islands over 1000 ha each including St. Ignace Island (274 km^2), Simpson I. (73 km^2), Wilson I. (19 km^2), Edward I. (16 km^2), Fluor I. (14 km^2), Vein I. (10 km^2) and Copper I. (9 $km^{2)}$. These islands have numerous arctic-alpine communities and colonial nesting waterbirds. The archipelago has remained largely undisturbed by development and has recently been protected as a Provincial Conservation Reserve. The islands are also part of an area currently being considered for establishment of a National Marine Conservation Area.

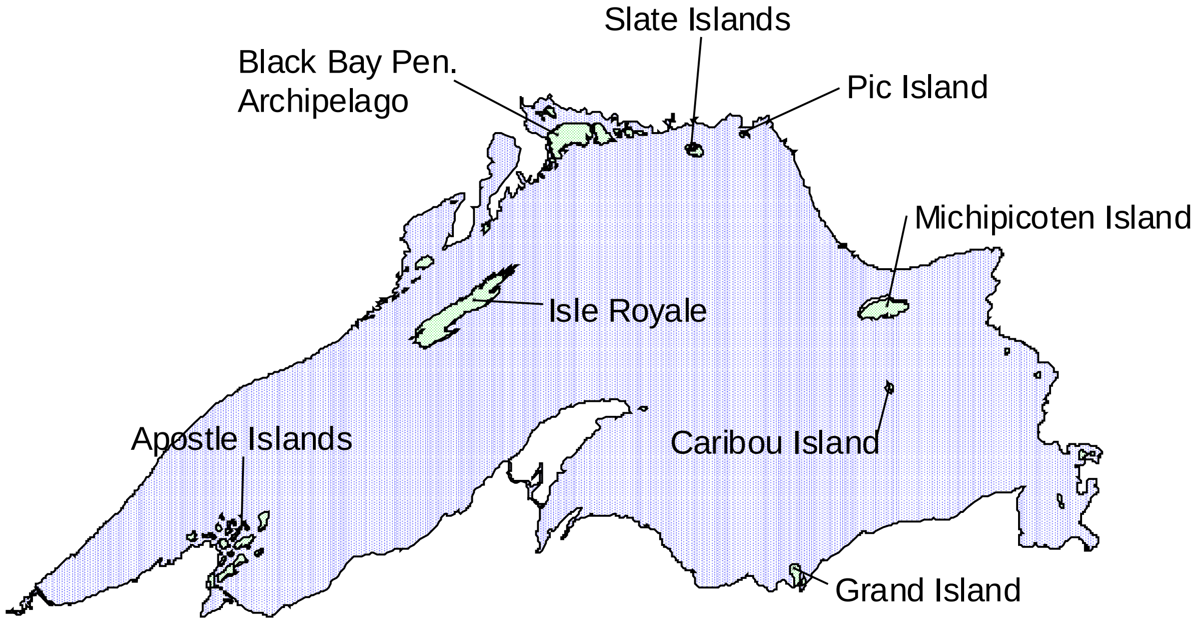


Figure 6-32. Major islands.

Michipicoten and Caribou Islands

Michipicoten is a large island (184 km^2) in eastern Lake Superior that has an introduced woodland caribou population. Caribou Island (12 km^2) is due south of Michipicoten Island, approximately 65 km from the mainland, and is notable for its isolation and as a rest stop for migrant birds. Michipicoten is a provincial park and Caribou Island is largely protected by its extreme isolation.

Pic Island

Pic Island is a small island (11 km^2) on the north shore of Superior that historically had woodland caribou and still has suitable woodland caribou habitat. Together with three adjacent islands, they have arctic-alpine plants and colonial-nesting birds. They have recently been incorporated into the adjacent Neys Provincial Park

6.1.6 Shorelines

Lake Superior's shorelines are a product of glacial activity, the influence of wave, wind, currents, and the continuous erosion and deposition of sediments. Shorelines provide a wide range of habitats depending on topography, substrate, geology, erosional processes and climate.

Shorelines offer a unique environment for plants and wildlife, substantially different from adjacent inland areas. Coastal shoreline habitats have a moderated climate and distinctive physical structures such as sand spits, bluffs and cobble beaches which address the needs of a diverse range of species.

Shoreline habitats also play a critical role for migrating wildlife, which respond to the natural barrier of water and make use of the available food sources. Open wetlands and beach areas are used by migrating shorebirds in spring and fall (Reid and Holland 1997). Many species of hawks avoid crossing the open water of Lake Superior instead making their way along shoreline bluffs on thermals and updrafts. Bird observatories at Whitefish Point Michigan, Thunder Cape Ontario and at Hawk Ridge Nature Reserve in Duluth are contributing significantly to the knowledge of shoreline migration corridors.

Human influences also tend to concentrate in or near shoreline habitats, and in some locations have had profound impacts upon the ecological integrity of these sites.

6.1.6.1 Shoreline Classification

The most comprehensive classification of Lake Superior shorelines are the Environmental Sensitivity Atlases compiled by Environment Canada (1993) and the United States National Oceanic and Atmospheric Administration (U.S. EPA 1994). Although primarily designed to assist in response to oil spills, these Canadian and U.S. atlases also provide data on Lake Superior's shoreline characteristics and features.

This classification system established a number of distinct shoreline habitat types. The U.S. approach to this shoreline classification strategy offered a slightly finer level of detail by providing a greater number of categorized shoreline types. However, both the Canadian and U.S. atlases, share a number similar physical themes, that when merged, provide a overview of shoreline habitat for the entire basin. Shoreline types are summarized in Figures 6-33 and 6-34, and Table 6-10.

Cliff

This feature includes bedrock cliffs of various heights comprised of resistant or impermeable bedrock surfaces. Many rare or unusual plant types have often been discovered in areas along these exposed, shallow soiled cliff tops where a "less competitive" growing environment offers suitable conditions for early colonization. This is the most extensive shoreline habitat type of Lake Superior, comprising 32 percent of the shore. Most cliff shores are in Canada, making up the predominant shoreline type on the outer islands and along the eastern shore (Figures 6-33 and 6-34.). In the U.S., cliffs are common in the Pictured Rocks area, Isle Royale and along the Minnesota north shore.

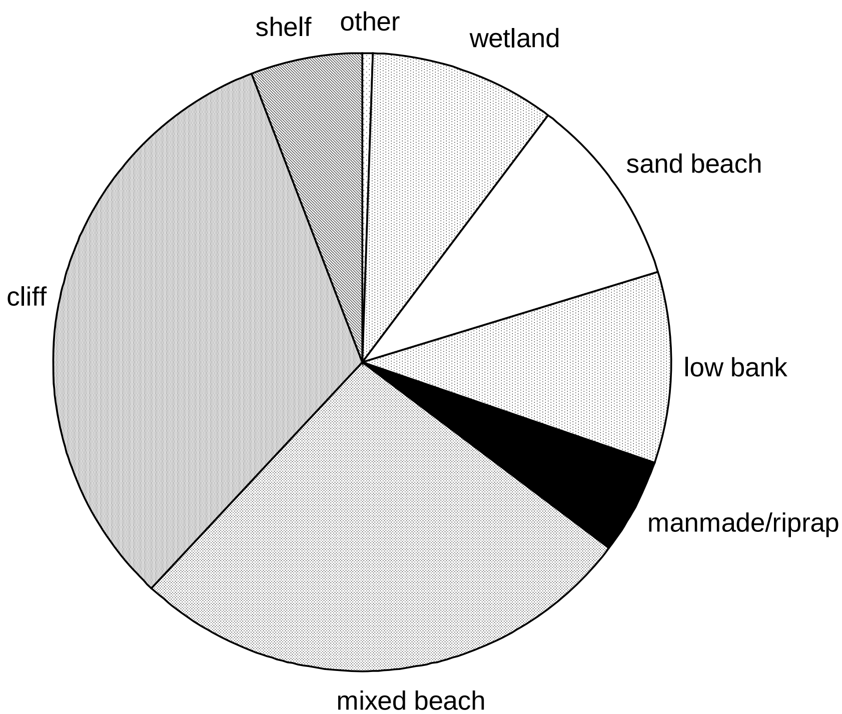


Figure 6-33. Lake Superior Shoreline

Shelf

This shoreline consists of wide flat expanses of bedrock, often also extending below normal water levels. In many cases these bedrock sites are significantly influenced by wave action. Exposure, cool temperatures and scarce soils often provide conditions very suitable for the habitation of arctic/alpine disjunct plant species. Shelving bedrock shoreline is found mainly in the U.S., particularly on Isle Royale and the Minnesota north shore.

Bluff

Bluffs, or scarps, are unconsolidated soil in an erosional state from wind, wave and surface water action. In many cases, they represent the source for sediment material and sands that are transported and deposited in locations the permit the formation of sand beaches. Bluffs are uncommon on Lake Superior, making up only 1 percent of the shoreline.

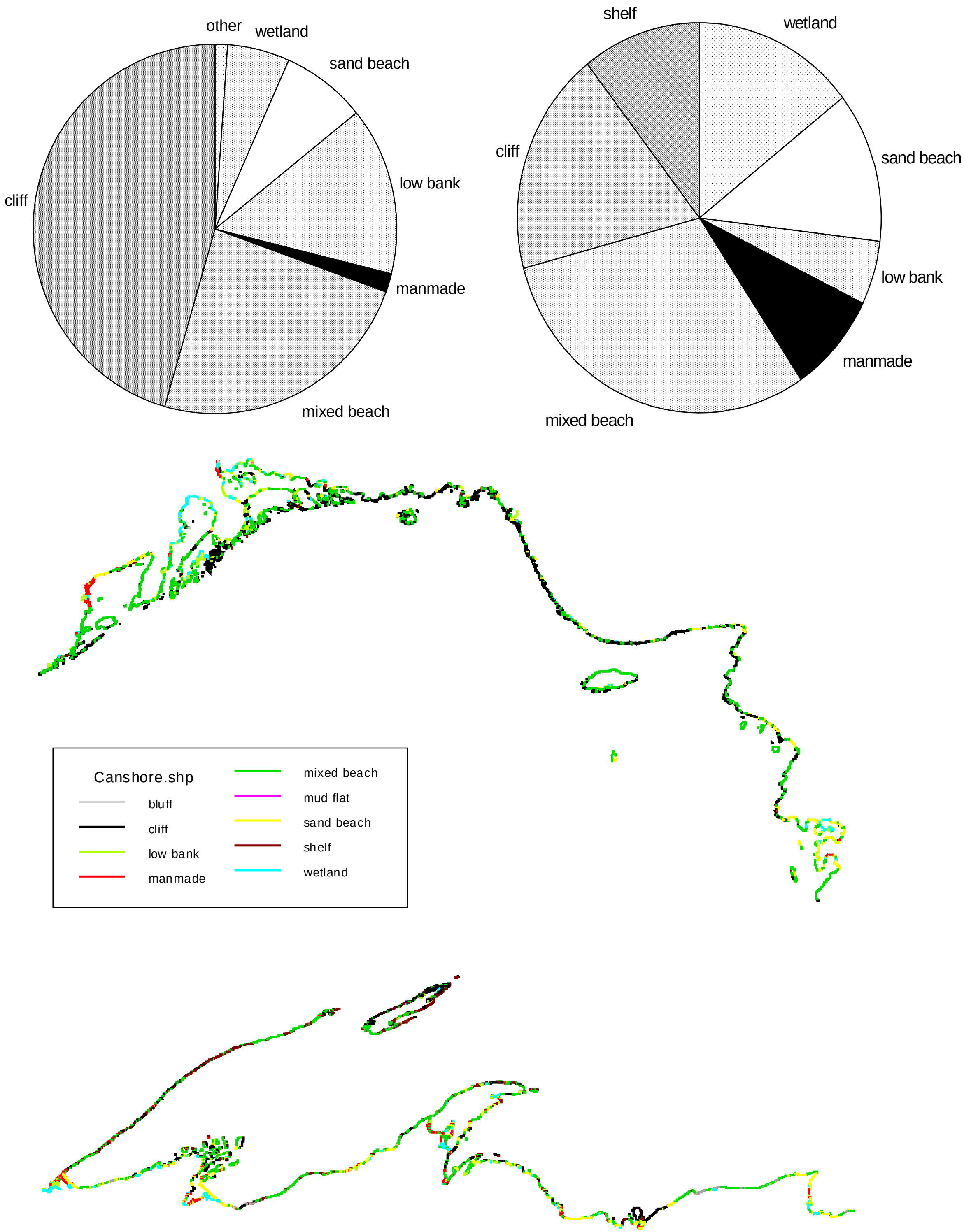


Figure 6-34. Lake Superior shoreline types
(compiled from U.S. EPA 1994 and Environment Canada)

Table 6-10 Physical features of Lake Superior shoreline (compiled from U.S. EPA 1994 and Environment Canada 1993)

	U.S.		Canada		Total	
	km	**%**	**km**	**%**	**km**	**%**
Cliff	607	18	1533	46	2140	32
Bedrock Shelf	344	10	36	1	380	6
Bluff	30	1	4	-	35	1
Sand Beach	409	12	256	8	665	10
Mixed Beach	980	30	797	24	1777	27
Low Bank	175	5	491	15	666	10
Mud Flat	2	-	1	-	3	-
Fringing Wetland	173	5	154	5	327	5
Extensive Wetland	294	9	25	1	319	5
Man-made Structure	112	3	22	1	134	2
Riprap	157	5	40	1	197	3
Total	**3283**		**3359**		**6643**	

Sand Beach

Sand beaches are formed where waves and wind and littoral drift deposit eroded particles. Artificial shoreline structures and the hardening of shorelines can have a serious impact on beaches by interrupting the process of longshore sediment transport that naturally erodes and replenishes beaches. Most sand beaches are on the eastern and southern shores of the lake, particularly in sheltered bays where wave action is less. Beaches are extremely rich areas for migrating shorebirds that feed on a variety of invertebrates. They also provide habitat for a disproportionately high number of rare species.

Mixed Beaches

Mixed beaches are a combination of sand, gravel, cobbles, and boulders, the proportions of which depend largely on the degree of exposure to wave energy. Cobble and boulder beaches are more common on wave-washed shores and sand/gravel beaches in more sheltered sites. Mixed beaches make up 27 percent of the Lake Superior shoreline. Exposed cobble beaches are largely devoid of vegetation but, in more protected areas they support mosses and lichens. Herbs, graminoids and woody plants are found farther from the limit of wave action. The spaces between cobble and other beach materials provide habitat for a variety of terrestrial and aquatic insects. Perhaps the most spectacular of this habitat type are the "raised cobble beaches" resulting from a combination of glacial rebound and receding lake levels. One of the more notable sites for "raised cobble beaches" is Cobinosh Island near Rossport, Ontario.

Low Banks

Low banks are shorelines with vegetation extending to the waterline. They make up only 10 percent of Lake Superior's shoreline. These are typically found in very well protected bays where they are sheltered from wind and wave scouring.

Mud Flats

Mud flats are typically found near the mouths of rivers where suspended sediments are deposited upon reaching the slow moving waters of Lake Superior. Less than 1 percent of Lake Superior's shoreline is mud flat.

Wetlands

Two categories of wetland shorelines are recognized. Fringing wetlands are marsh communities, characteristically found in shallow water coves protected from wind and waves. They closely border the shore to form a narrow belt of aquatic vegetation. Because urban and cottage sprawl also tend to focus lake front developments in sheltered coves, wetlands tend to be a shoreline habitat particularly susceptible to human impacts. Extensive wetlands are larger (up to 1 to 2 km long) and occupy shallow coves with stream outlets. On Lake Superior marsh communities are the most common type of broad wetland. These two wetland shoreline types make up 5 percent of the Lake Superior shoreline, with most of the extensive wetlands in the U.S.

Manmade Structures

This category includes retaining walls, harbour structures, sheet piling, breakwaters, and riprap. This type of shore is usually found in close proximity to urban/industrial areas. Riprap is comprised of rock material placed to protect shoreline property. Solid straight-line man-made structures, provide little habitat for terrestrial or aquatic life. In some instances, riprap can enhance fish habitat by providing a suitable spawning substrate, but habitat for plants and animals dependant of soft substrates is lost. Gulls frequently use breakwaters for resting, feeding and nesting. Collectively, manmade shorelines make up 5 percent of the Lake Superior shore, mainly in the U.S.

6.1.7 Wetlands

Wetlands often form the link between the terrestrial environment and Lake Superior. They provide habitat for fish and wildlife, protect shoreline areas from erosion, buffer runoff following storm peaks and contribute to the diversity of habitat types in the basin.

Wetlands can be classified in different ways. One of the most widely accepted classifications recognizes five major categories of wetlands. **Bogs** are peatlands (ie. wetlands with more than 40 cm of organic soil) where the surface is isolated from contact with mineral rich ground water. They are acidic and nutrient-poor. **Fens** are peatlands that are nourished by groundwater flow and are therefore richer than bogs. **Swamps** are dominated by trees or tall shrubs and have standing or gently moving waters. They have organic or mineral soil. **Marshes** are flooded by standing or slowly moving water for all or part of the year and are usually associated with lakes or streams. **Shallow open water wetlands** are like marshes, but are dominated by submergent and floating-leaved plants (NWWG 1988).

Wetlands can also be classified by and aquatic system (lacustrine, riverine, estuarine, palustrine) and site type (e.g. open embayment, barrier beach lagoon, dune and swale complex, etc.) (Chow-Fraser and Albert 1998).

Total wetland coverage (excluding marshes and shallow water) is estimated at 15 percent of the U.S. basin (Table 6-11). Estimates range from 781 km^2 (10 percent of the basin) in Wisconsin to 3379 km^2 (21 percent of the basin) in Minnesota. A different estimate of Minnesota's wetland area using National Wetland Inventory (NWI) data puts the total for the basin at 31 percent of the land base (MPCA 1997). Differences in estimates of total wetland area are due to different techniques and definitions of wetlands. Digital NWI data is unavailable for Wisconsin and Michigan.

Table 6-11 Wetland area for the U.S. Lake Superior basin (exclusive of open water and deep marsh wetlands) (data from Lake Superior Decision Support Systems)

Wetland Class	Total Area (km^2)	% of Basin
Michigan		
Forested	1935	10
Non-Forested	366	2
Subtotal	2301	11
Minnesota		
Forested	3067	19
Non-Forested	312	2
Subtotal	3379	21
Wisconsin		
Forested	699	9
Non-Forested	82	1
Subtotal	781	10
Total U.S.	**6461**	**15**

Minnesota's wetlands are mostly bog, fen and swamp, typically in palustrine environments. Marshes and shallow open water are mostly found on inland lakes and streams (Wright and others1988, MPCA 1997) (Figure 6-35).

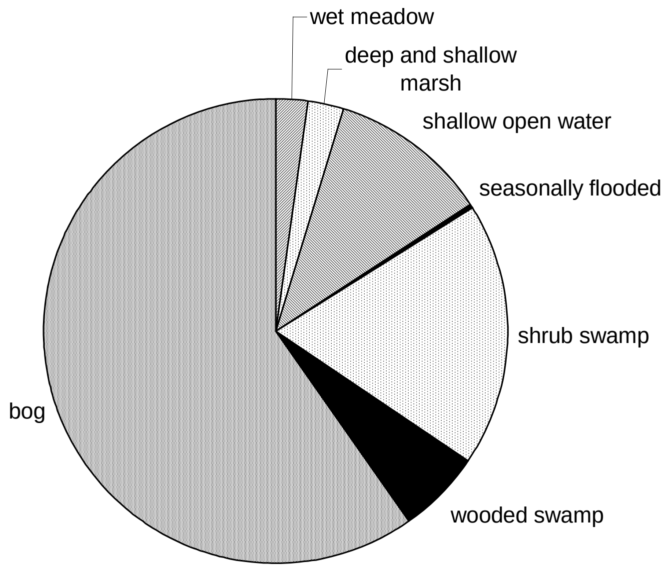


Figure 6-35. Proportions of wetland types for the Minnesota Lake Superior basin - "bog" includes bog and fen (MPCA 1997)

The most heavily concentrated areas of wetland in the U.S. basin are in western Minnesota and eastern Michigan (Figure 6-36). The St. Louis River watershed is 41 percent wetland, with extensive peatlands in the central watershed (MPCA 1997). Large peatlands in Luce and Chippewa counties in Michigan are also noteworthy (Crum 1988).

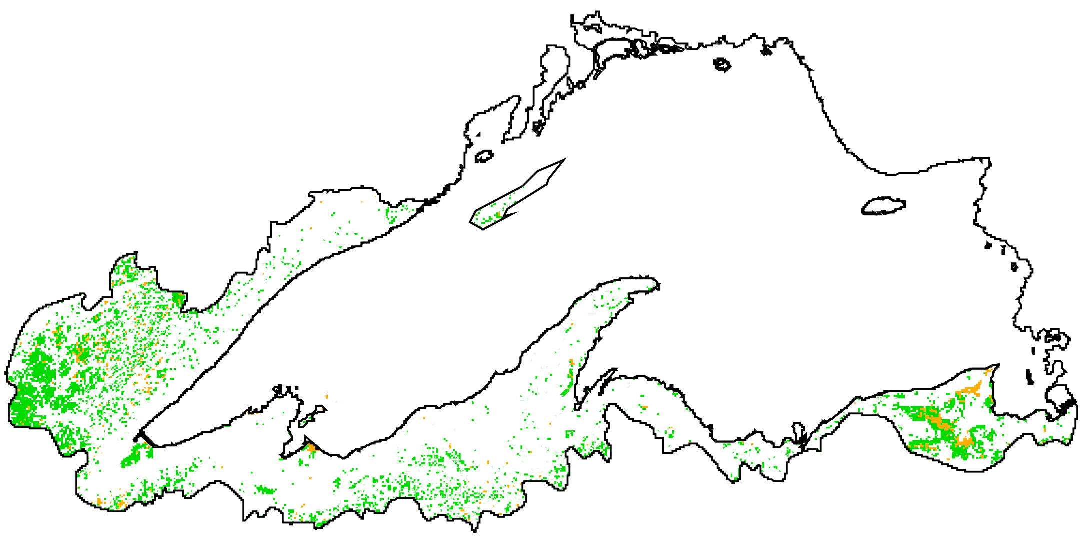


Figure 6-36. Forested (green) and non-forested (orange) wetlands in the U.S. Lake Superior basin (Lake Superior Decision Support Systems data)

Detailed data are unavailable for Ontario, but the area surrounding the basin is estimated at 6 to 25 percent wetland cover by area (Figure 6-37) (NWWG 1988). Wetlands in Ontario are concentrated in the eastern and western ends of the basin. The Ontario basin is within the "Low Boreal" and "Humid Mid-Boreal" wetland regions, where the most common wetland types are bogs, fens and coniferous swamps.

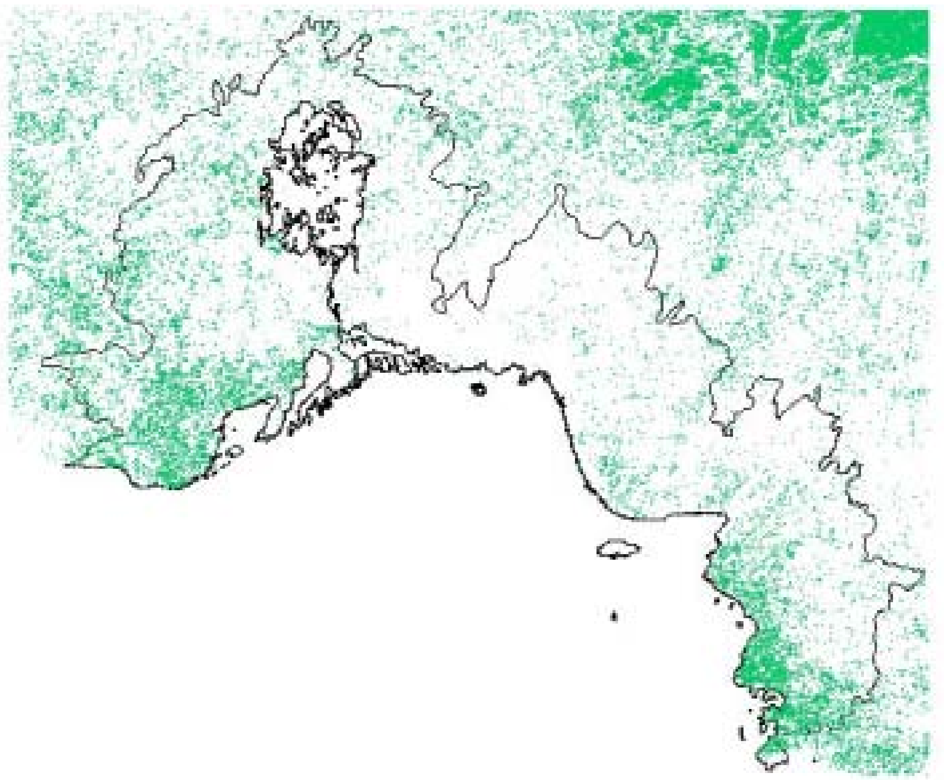


Figure 6-37. Wetlands in the Ontario Lake Superior basin (OMNR data)

6.1.7.1 Coastal Wetlands

Coastal wetlands make up 10 percent of the Lake Superior shore (Table 6-11, Figure 6-38) mostly associated with protected bays, estuaries and barrier beach lagoons (Chow-Fraser and Albert 1998). Lake Superior coastal wetlands consist of small lacustrine marshes dominated by spikerush (*Eleocharis smallii)* and hardstem bulrush (*Scirpus acutus)* with richer submergent communities in more sheltered estuaries. Narrow bands of wet meadow with bluejoint grass (*Calamagrostis canadensis*) and sedges (*Carex* spp) and thicket swamp with willows (*Salix* spp.) and alder (*Alnus incana*) occupy the seasonally-flooded zone. Fens are found above the level of contact with lake water, where organic soil accumulates. Sphagnum moss and ericaceous shrubs are the dominant plants.

In Ontario, coastal wetland development is restricted by high wave energy. Extensive coastal wetlands are confined to Thunder Bay, Black Bay and Nipigon Bay (Figure 6-38). Fringing wetlands are associated with Black Bay Peninsula and Nipigon Bay. There is very little coastal wetland on the eastern half of the Ontario shore. Ontario's coastal have a total area of approximately 4400 ha (Wilcox and Maynard 1996). Because of their scarcity, Ontario's coastal wetlands are very important to fish and wildlife (Maynard and Wilcox 1997). Only about 10 coastal wetlands have been evaluated on Lake Superior, mostly near Thunder Bay (Maynard and Wilcox 1997). At least 3,500 ha of coastal wetland remains to be evaluated (Wilcox and Maynard 1996).

The U.S. side of the lake has approximately 17,400 ha of coastal wetland (Wilcox and Maynard 1996). Coastal wetland is rare on the Minnesota northshore due to the smooth steep shoreline. The stretch of shoreline from Duluth to Marble Point, Wisconsin has perhaps the most abundant and richest coastal wetlands on Lake Superior. Most are associated with the Lake Superior Clay Plain where estuaries and barrier beaches offer shelter from waves and wind (Epstein and others 1997). Wisconsin's coastal wetlands have been thoroughly inventoried and described (Epstein and others 1997).

Michigan's coastal wetlands are scattered at stream mouths from the Keweenaw Peninsula to Sault Ste. Marie. Extensive dune and swale and barrier beach wetlands are along the sandy shore between Whitefish Bay and Sault Ste. Marie (Chow-Fraser and Albert 1998).

6.1.7.2 Threats

The greatest threats to Lake Superior's wetlands are water level regulation and site-specific stresses such as shoreline development (Chow-Fraser and Albert 1998). Other threats include invasive species and diminished water quality (Epstein and others 1997).

Loss of wetland habitat has been small in Cook (0 percent loss) and Lake (2 percent loss) counties, Minnesota (MPCA 1997), but most of the St. Louis River estuary wetlands at Duluth / Superior have been lost since the early 1900's (Epstein and others 1997). The wetlands of the Apostle Islands, Bad River and Kakagon Slough are largely intact (Chow-Fraser and Albert 1998).

Wetland loss in Ontario has not been quantified, but is probably low (0 – 25 percent) for most of the basin, given the low intensity of land use (Detenbeck and others 1999). In local areas, however, wetland losses are substantial. Wetland area around the city of Thunder Bay was has declined by over 30 percent since European settlement (NWWG 1988). Lake Superior shoreline wetlands are a particular concern in Ontario, given their scarcity and proximity to developed areas. Continued cottage development at Cloud Bay, Sturgeon Bay and Pine Bay threatens wetlands (Maynard and Wilcox 1997).

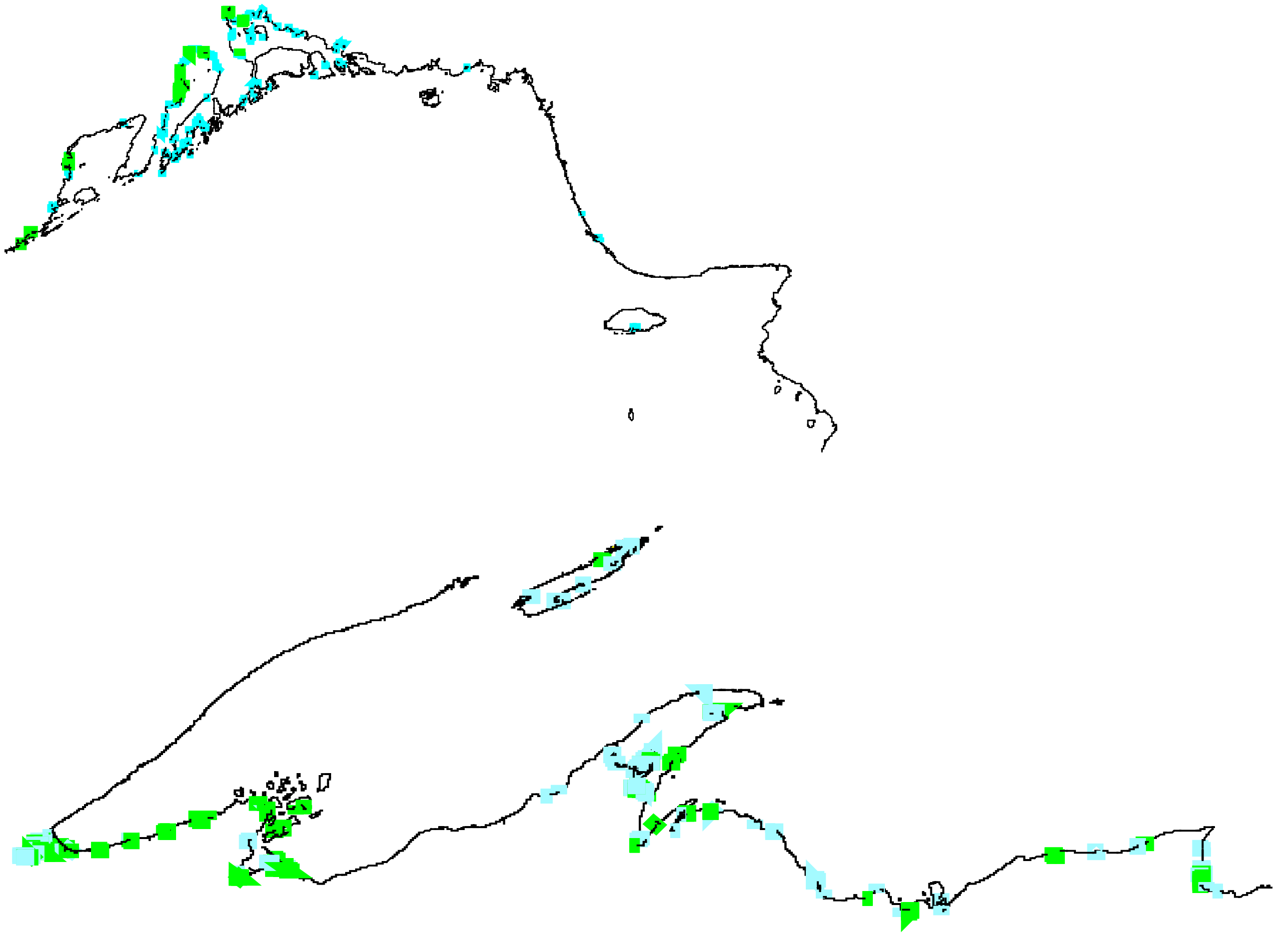


Figure 6-38. Lake Superior shoreline wetlands: extensive (green) and fringing (blue) (compiled from U.S. EPA 1994 and Environmental Canada 1993)

No estimate is available for the amount of coastal wetlands lost on Lake Superior. No large-scale losses have occurred along the north shore because the shoreline is remote and sparsely populated. However, considerable wetland area has been lost within the Areas of Concern at Thunder Bay, Nipigon Bay, Jackfish Bay, and Peninsula Harbour due to shoreline modification and urban encroachment (Wilcox and Maynard 1996). On the other Great Lakes, 11 – 100 percent of historical wetland area has been lost (LSBP 1995a). Nutrient enrichment and toxic contamination of waters and sediments and modified water level fluctuations are other potential threats to Lake Superior wetlands (Wilcox and Maynard 1996).

Water level regulation on Lake Superior has affected all coastal wetlands by restricting the natural flooding and drawdown cycle. In an unregulated wetland, periodic flooding kills back woody species along the fringe, allowing less competitive wetland plants to occupy the zone. Drawdown below the average water level allows the seed bank to germinate and promotes oxidation of substrates. Maintaining relatively constant water levels result in a smaller and less diverse wetland zone. On Lake Superior, although the flooding – drawdown cycle hasn't been altered substantially, the extreme low water levels are probably not frequent enough to maintain natural wetland conditions (Maynard and Wilcox 1997). No data on changes in wetland vegetation due to water level regulation are available. Similar effects occur on wetland on inland lakes and streams with altered water level regulation (Wilcox and Whillans 1999).

Shoreline alteration influences wetlands, both through direct loss of wetland area and disruption of hydrological and sedimentation processes. Wetlands enclosed by groins, dykes and breakwalls have reduced supplies of sediments that naturally nourish the shoreline and replace eroded sediments (Maynard and Wilcox 1997). By obstructing natural disturbances, such as storms and ice-scour, man-made structures cause shifts in plant species composition of enclosed wetlands.

6.1.8 Tributary Streams

Lake Superior has an estimated 1,525 tributaries (840 in the U.S. and 685 in Canada) (Lawrie and Rahrer 1973). These include permanent as well as intermittent streams. In addition, there are thousands of tributaries that flow into inland lakes or other streams rather than directly into Lake Superior) (Figure 6-39). Collectively, these streams add up to over 30,000 km of habitat (Figure 6-40).

Many of the tributaries are short, due to the relatively small, steep watershed. Some of the largest tributaries are the Nipigon, St. Louis, Kaministiquia, and Pic rivers (Figure 6-41, Table 6-12).

The wide diversity of geology and soils around the basin contribute to a diversity of different stream habitats. However, streams have not been thoroughly inventoried or classified and the various jurisdictions around the basin differ in the amount and kinds of information available. The Nature Conservancy has started an initiative to classify all streams in the basin using geographical information system data (Jonathan Higgins, Michele DePhilip personal communication), but results are not available yet.

In general terms, many streams are high gradient, cold water environments supporting brook trout, sculpins, dace and introduced salmonids. Slower moving low gradient streams support cool and warmwater fish communities. Wisconsin has the most exhaustive stream inventory (Turville-Heitz 1999). Most Wisconsin streams that have been classified are coldwater trout streams (Figure 6-42). Minnesota north shore streams are numerous and short with steep gradients. They are "…deeply entrenched and characterized by swift flows, many rapids and waterfalls, and especially steep gradients in the lower 3 to 5 miles before entering Lake Superior…" (MPCA 1997). Streams in the St Louis River watershed have smaller gradients.

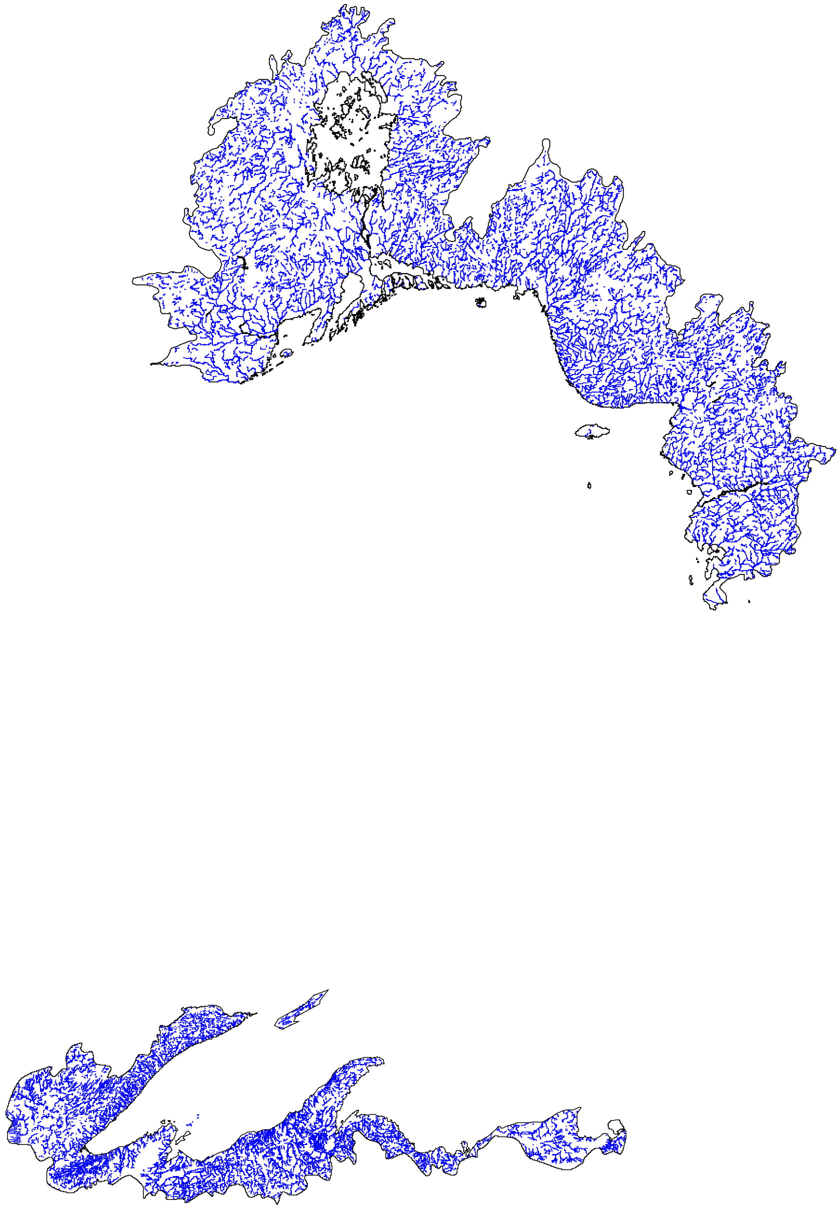


Figure 6-39. Perennial streams in the Lake Superior basin (Lake Superior Decision Support Systems and OMNR data) - Note stream mapping standards differ between jurisdictions

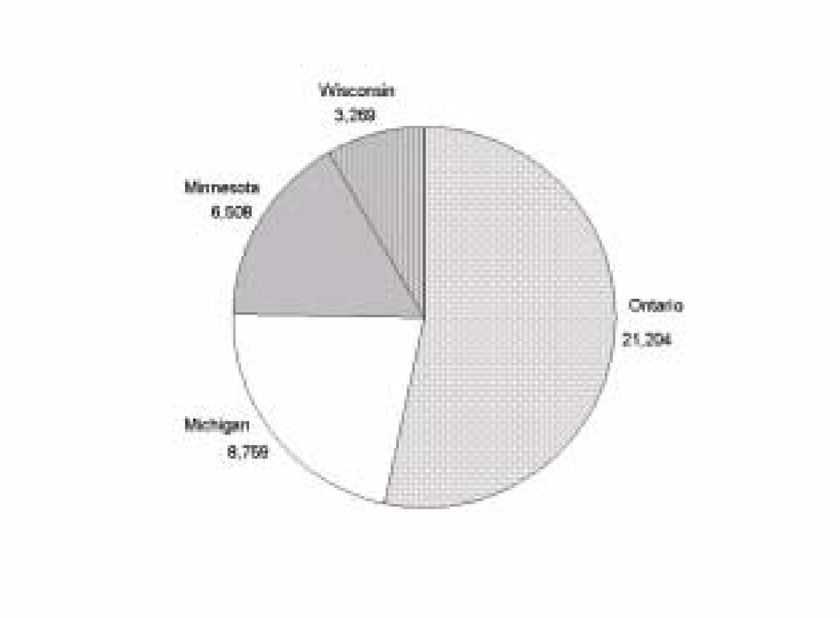


Figure 6-40. Perennial stream lengths (km) in the Lake Superior basin (derived from OMNR and Lake Superior Decision Support Systems NRRI data) Note stream mapping standards differ between jurisdictions

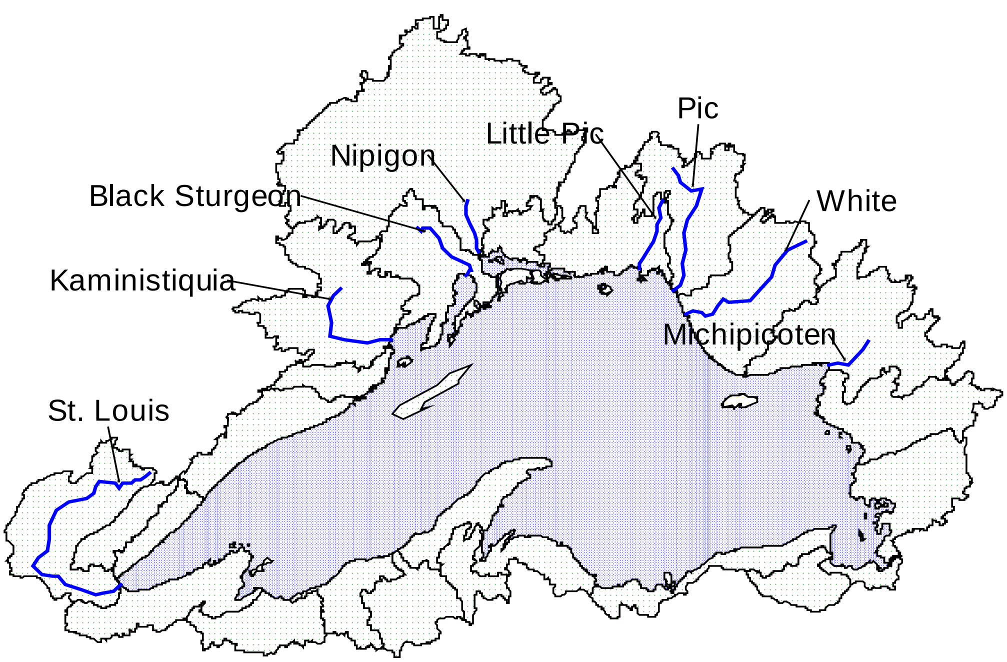


Figure 6-41. Major watersheds and rivers (Lake Superior Decision Support Systems data)

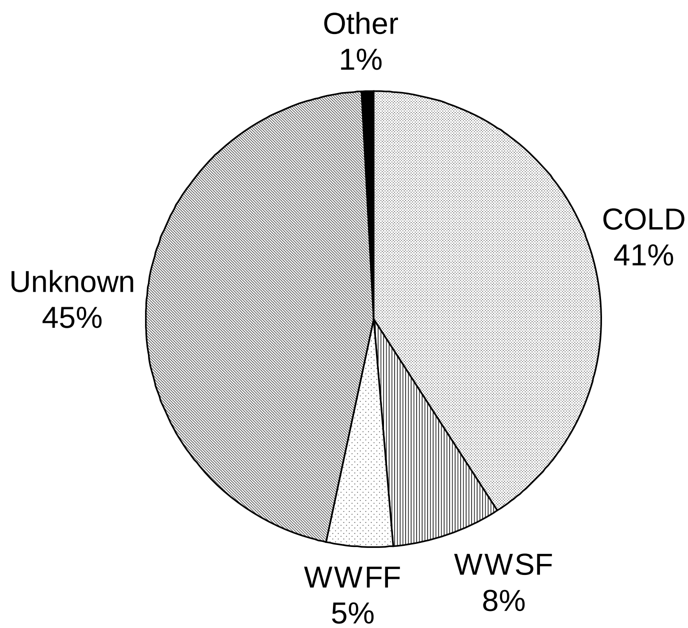


Figure 6-42. Classification of Wisconsin streams in the Lake Superior basin COLD is cold water fishery including trout stream; WWSF is warm water sport fishery; WWFF is warm water forage fishery; "Other" includes limited forage fishery and limited aquatic life (from Turville-Heitz 1999).

Table 6-12 Some major Lake Superior tributaries (OME 1992, MPCA 1997)

River	Flow (m^3/s)	Length (km)
Nipigon	331	50
St. Louis	258*	288
Pic	65	-
Kaministiquia	61	-
Michipicoten	36	128
Little Pic	19	158
Black Sturgeon	19	90

* approximate value determined downstream from confluence of Cloquet River

Sedimentation, changes in runoff on the landscape level related to clearcutting, agriculture and urbanization have greatly changed habitats on the lower Great Lakes. Impacts on Lake Superior are smaller due to the lower human population, but local problems do occur and the cumulative effects of many small changes are unknown.

6.1.8.1 Accessible Stream Length

The length of accessible tributary stream habitat is a potential limiting factor for Lake Superior's migratory fish populations. Accessible stream length can be limited by natural (e.g. falls) or man-made (e.g. dams) barriers.

On the Canadian side, there is an estimated 1091 km of stream available to anadromous fishes (Steedman 1992). The U.S. side has an estimated 3171 km of accessible stream (Table 6-13). The method of determining the length probably differs between jurisdictions. Data for individual streams is in presented in Addendum E.

Accessible stream length has decreased due to construction of dams, lamprey barriers, and other man-made structures. Estimates of the decrease in available habitat are not available. Power dams are the lowest barrier on some significant tributaries, including the Black, Michipicoten and Montreal rivers, but the decrease in accessible stream is not easily determined because dams sometimes are constructed at natural barriers (falls or rapids).

Removal of man-made barriers and construction of fish passage devices, such as fish ladders can increase the amount of available stream habitat.

Table 6-13 Summary of Lake Superior tributaries known to contain anadromous fishes (compiled by Mark P. Ebener; Ontario total from Steedman 1992)

Management Unit	Available habitat (km)	Number of tributaries										
		Chinook salmon	Coho salmon	Atlantic salmon	Pink salmon	Rainbow trout	Brown trout	Brook trout	Lake trout	Lake white fish	Walleye	Lake sturgeon
MN-1	218	4	1			21	1	10			1	1
MN-2	12	1	1			24	1	22				
MN-3	35	1				20		20			1	1
WI-1	250	4	3			6	6	1			5	
WI-2	273	6	10			10	8	3			3	1
MI-1	77		1			7		11				
MI-2	900	4	6	2		18	7	9			4	
MI-3	200	1	8			19	5	11			1	

Table 6-13 Summary of Lake Superior tributaries known to contain anadromous fishes (compiled by Mark P. Ebener; Ontario total from Steedman 1992)

Management Unit	Available habitat (km)	Number of tributaries										
MI-4	457	1	12		4	24	5	14			9	1
MI-5	217	8	8		7	13	5	12			7	
MI-6	142	4	7		5	13	4	7		1	3	
MI-7	94	3	5		6	6	1	5			2	
MI-8	296	6	9		5	12	2	8			3	1
ON-1	6				1	3		3			2	
ON-2	?										3	
ON-4	?	1									5	
ON-5	?	1									5	
ON-6	22	1	1		1	2		1			1	
ON-7	17	2	2		2	2		2			2	1
ON-10	?	1						2				1
ON-11	?							2			2	1
ON-12	?										2	
ON-18	6	1	1	1	1	2		1			1	
ON-19	?										1	
ON-23	2	4	1			3		2			4	1
ON-24	?					1		1				
ON-28	?	1				1			1		2	1
ON-31	?							2			1	
ON-33	18	1	2		1	4		3	1		6	
ON-34	37	1	1		1	1					3	1
U.S. Total	**3171**	**43**	**71**	**2**	**27**	**193**	**45**	**133**	**-**	**1**	**39**	**5**
ON Total	**~1091**	**14**	**8**	**1**	**7**	**19**	**0**	**19**	**2**	**-**	**40**	**6**

6.1.8.2 Stream Water Quality

Ontario

The Ontario Ministry of the Environment (OME) monitors 37 streams background levels and to assess impacts of point source pollution. These sites include the mouths of some major tributaries. A summary of selected stream parameters is presented in Addendum D. OMNR has conducted surveys on 65 tributary streams (Addendum C).

Seventeen Ontario streams have habitat impairments due to point source pollution, siltation, urban runoff and other causes (Table 6-14). Five of these streams (McVicar Creek, McIntyre River, Neebing River, and Kaministiquia River) run through the City of Thunder Bay and receive urban runoff as well as industrial effluent. Four streams near the Hemlo gold fields are contaminated by mine waste (Cedar Creek, Fox Creek, Hayward Creek, Upper Black River). A

1992 report (OME 1992) noted some improvements in pulp mill effluent and urban sources, but there are continued problems, especially during low water levels. No current (post 1992) summary is available.

Fish habitat has also been degraded by historical logging practices, such as log drives, logging of banks and erosion from road crossings (Lawrie and Rahrer 1973). Logging, and associated road crossings, has taken place in all the major watersheds. In Ontario, application of habitat guidelines (OMNR 1988a, 1988b) have improved stream side logging practices, but landscape-level impacts of logging impacts across the watershed are unknown. Ontario streams have a wide range of natural turbidity levels due to differences in soil types. This makes it difficult to distinguish the influence of natural erosion processes and man-made causes.

Table 6-14. Ontario streams with habitat impairments (OME 1992, OMNR unpublished data)

Stream	Impairment	Source of Impairment	Receiving water
Agawa River	Channelization		Lake Superior
Blackbird Creek	BOD, pH, coliform bacteria	Pulp and paper mill effluent	Lake Superior
Cedar Creek	Phosphorus, nitrogen, fecal coliform bacteria	Diffuse source – extractive industrial land	Black River, Pic River
Current River	Fecal coliform bacteria	Rural and urban runoff	Lake Superior
Deadhorse Creek	Siltation		Lake Superior
East Davignon Creek	Siltation, pollution, low summer flow, BOD, high temperatures,	Urban runoff, industrial effluent	Lake Superior
Fox Creek	Sulphates, metals, pH	Diffuse source – extractive industrial land downstream from mine seepage	Black River, Pic River
Hayward Creek	Conductivity, chlorides, sulphates, metals, phosphorus, pH	Mine effluent	White River
Little Cypress R.	Erosion, low summer flows, High temps, barrier	Highway washout	Lake Superior
Little Pic River	Siltation		Lake Superior
Lower Kaministiquia River	BOD, suspended solids, phosphorus, nitrogen, metals, fecal coliform bacteria	Industrial point sources, pulp and paper mill effluent, sewage treatment plant	Lake Superior
McIntyre River	Chlorides, conductivity, metals	Rural and urban runoff	Lake Superior
McVicar Creek	Alkalinity, chlorides, conductivity	Urban runoff	Lake Superior
Michipicoten	Water fluctuations	Power dam	Lake Superior

Table 6-14. Ontario streams with habitat impairments (OME 1992, OMNR unpublished data)

River			
Neebing River	Alkalinity, phosphorus, organic nitrogen, fecal coliform bacteria	Rural and urban runoff	Lake Superior
Rudder Creek	Alkalinity, BOD, chlorides, conductivity, nutrients, suspended solids, sulphates, fecal coliform bacteria	Municipal sewage	Pic River
Upper Black River	Sulphates, conductivity, ammonia	Diffuse source – extractive industrial land and point source, mining	Pic River

Minnesota

The Minnesota Pollution Control Agency (MPCA) assesses selected streams for Aquatic Life Use Support, "to determine if waters are of a quality to support the aquatic life that would be found in the stream under the most natural conditions" (MPCA 1997). The assessment is based on water chemistry data, biological and habitat information and a survey of local resource managers. Note that the data presented in and is based on a subset of the streams.

Water quality in north shore streams is typically quite good (Table 6-15) (MPCA 1997). "Threatened" streams do not show signs of degradation, but are likely to show signs of degradation due to future changes in the watershed. Turbidity, metals, and habitat alteration are the most common indicators of impairment with silviculture, construction and land disposal as the suspected pollution sources (Figure 6-43).

The 39 km of the Nemadji River that has been assessed is "not supporting" due to turbidity and habitat alteration from a hydroelectric dam. The 12 km of the Cloquet River that has been assessed is not supporting due to metals from non-point sources.

The lower St Louis River is polluted from industrial effluent, stormwater runoff, and other sources. This area is covered by a Remedial Action Plan has shown improvements in water quality. Contaminated sediments, stormwater runoff and leaky landfills continue to pollute the river. In addition to water quality impairments, human activity has altered habitat in more than 58 percent of the St. Louis River Estuary through dredging, shoreline modification and filling of wetlands.

Table 6-15 Minnesota stream assessments for aquatic life (MPCA 1996)

Watershed	Length Assessed (km)	Fully Supporting	Threatened	Partially Supporting	Not Supporting	Not Attainable
Lake Superior – North	251	23%	77%	-	-	-
Lake Superior – South	182	3%	41%	23%	34%	-
St. Louis River	432	-	23%	3%	72%	3%
Cloquet River	12	-	-	-	100%	-
Nemadji River	39	-	-	-	100%	-

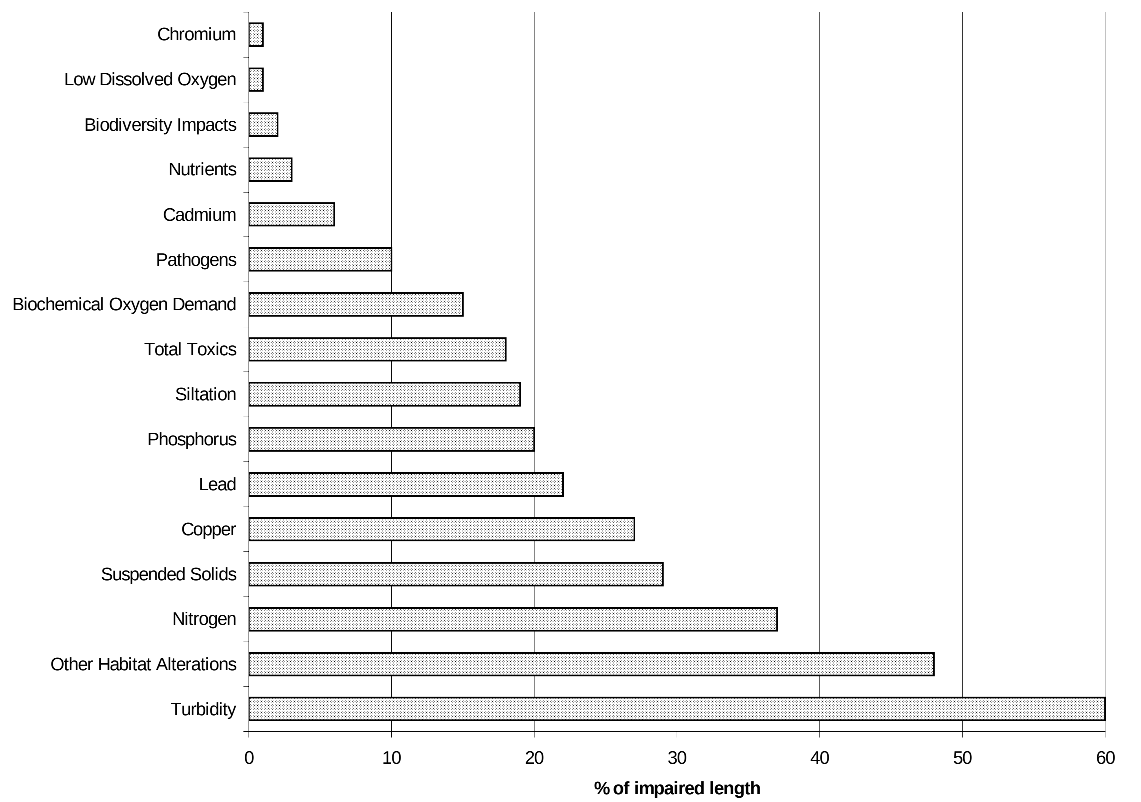


Figure 6-43. Causes of Habitat Impair

Wisconsin

Wisconsin has a detailed inventory and discussion of habitat conditions of streams in the Lake Superior Watershed (Turville-Heitz 1999). Table 6-16 summarizes the habitat conditions of all Wisconsin Lake Superior tributaries. The relatively large amount of Threatened habitat is mostly due to potential impacts of exotic species or land use activities within the watershed, even where there are no observed effects.

One of the major sources of turbidity and sedimentation in Wisconsin tributaries is related to the unstable red clays soils of the Lake Superior Clay Plain (see the following text box).

Table 6-16 Wisconsin Lake Superior tributaries (from Turville-Heitz 1999)

	Watershed	No. Streams	Total Stream Length (mi)	Watershed Area (mi^2)	Supporting Potential Use (%)				
					Full	Part	Not	Thr	Unk *
LS01	St. Louis and Nemadji rivers	78	284	159	7	12	3	22	78
LS02	Black and Upper Nemadji rivers	52	180	126	12	-	-	45	88
LS03	Amnicon and Middle rivers	107	384	289	23	-	-	-	77
LS04	Bois Brule	72	165	195	27	2	-	49	71
LS05	Iron River	36	147	218	9	-	-	79	91
LS06	Bayfield Peninsula Northwest	56	172	236	1	-	-	52	99
LS07	Bayfield Peninsula Southeast	56	142	302	3	2	4	56	91
LS08	Fish Creek	35	115	157	9	23	3	36	66
LS09	Lower Bad River	18	129	124	-	-	-	95	100
LS10	White River	67	271	360	tr	tr	-	75	99
LS11	Potato River	46	160	140	2	-	-	47	98
LS12	Marengo River	85	261	218	-	-	-	47	100
LS13	Tyler Forks	46	124	79	-	-	-	35	100
LS14	Upper Bad River	62	194	135	-	-	-	28	100
LS15	Montreal River	80	264	226	19	-	-	62	81
LS16	Presque Isle River	53	91	108					
	Total	**949**	**3083**	**3072**					

* stream can be both “Threatened” and “Unknown” if potential impacts have been identified

The St. Louis and Nemadji watershed has been discussed in the Minnesota section. Tributaries within the Wisconsin part of the watershed with impaired water quality include Crawford Creek, an unnamed Drainage to Crawford Creek, and Newton Creek. Impairments are due to sediment contamination, point sources of pollution, aquatic toxicity and other contaminants.

Habitat in the Fish Creek Watershed has been impacted by pathogens from sewage treatment plant and stormwater runoff from the City of Ashland. Other concerns are habitat loss, sedimentation and turbidity from unfenced pastureland, barnyard runoff, and logging (Turville-Heitz 1999).

Stream habitat in the Montreal River watershed has been altered by hydrological modification. There are only six hydroelectric dams in the Wisconsin basin, three of which are in the Montreal River watershed (the others are in the White, Iron, and St. Louis watersheds). Wisconsin's watersheds are small and provide inconsistent flows. Another 5 or so former dams have been removed (Turville-Heitz 1999).

Changes in Pre-European Forest Covertype on the Red Clay Plain and Stream Erosion (J. Gallagher)

Between the late 1800s and early 1900s, the Lake Superior Clay Plain underwent substantial disturbance in association with European settlement. Effects of this disturbance still impact hydrologic processes in the clay plain today. Analyzing what disturbance forces took place, how they changed the forest landscape, and the impacts these had on forest hydrology can be helpful to planners who are applying management practices to improve stream habitat.

Although the disturbance period was initiated by timber harvest, primarily of white pine, fire and artificial drainage of upland surface water associated with agriculture and road development produced some of the greatest changes to the landscape.

Geologically speaking this landscape is relatively young. The last glacial deposit occurred between 9500-11,000 years BP, when receding glacial ice retreated into the Superior basin and than later advanced, depositing a thin layer of clay till, Miller Creek Formation, over a deeper previously deposited coarser textured till, Copper Falls Formation (Clayton, 1984).

Young glacial landscapes generally have rapid erosion rates with geologic aging. Compounding this fact is the manner that the deposits occur. The clay till has fine clay texture and is strongly bonded. Beneath the clay lies coarse textured till, loosely bonded, and unconsolidated. Major streams have long ago cut through the clay till into the unconsolidated till. Water flowing in these streams, particularly during flooding, has been cutting away the loosely bonded till well before pre-European settlement. Streams eroding loosely aggregated channel sides are not uncommon, however the existence of the surface red clay cap has a two-punch effect in producing high erosion rates along these clay plain streams.

- Strongly bonded clay caps above a bend in a stream channel, where the loose material is being eroded, slows the stabilization process of the slope above the channel. This results in long steep mass wasting slopes immediate to the stream channel.
- Water infiltration rates in uplands covered by red clay till are very slow. Runoff is very rapid during rainfall and snowmelt events creating frequent flooding in streams. These floods produce high-energy water flows that frequently erode stream channels compounding the problem of mass waste erosion on adjacent slopes.

Undoubtedly some of this rapid erosion occurred prior to European settlement, but there were factors in the forested landscape that buffered runoff and erosion in streams. After European settlement, and the disturbance that came with it, much of this buffering was diminished, resulting in increased erosion rates.

Forest Cover

Keeping in mind this characterization of the surficial geology and the effects it has on stream erosion processes, the following is a simplified description of what pre-European forest conditions were like in the clay plain. This description also includes changes that occurred in forest cover, what forest cover conditions are today, and finally the impacts these changes have had on forest hydrology in the clay plain.

Based on survey information (Finley et.al. 1976) the pre-European forest cover on the clay plain was predominantly coniferous. To the east of the Douglas/Bayfield county line and continuing to the eastern extent of the clay plain there was an increase of northern hardwood species associated with this coniferous forest. White pine was the predominant overstory species in number and stature. White spruce and balsam fir created a dense sub-overstory canopy beneath the white pine in the western clay plain. To the east sugar maple, yellow birch, and hemlock were mixed with the fir and spruce. White birch and aspen were common associates throughout the clay plain. Their presence was associated with natural disturbance in the forest.

At a smaller scale of forest cover, in ravines vs. uplands, there were some interesting differences in forest composition. More mature forest conditions, predominance of larger diameter white pine associated with dense spruce-fir and cedar trees occurred in ravines. Uplands had a more even size class distribution of white pine. Also white birch and aspen were more common in the upland forest (Koch, 1980). One conclusion to be drawn from this difference in cover type is that natural disturbance was more common in the uplands and ravines provided protection from disturbance. Later succession forest conditions in ravines likely had well-developed vertical structure of live standing and dead downed woody debris.

Forest floors associated with these conifer forest cover types accumulated organic matter and a fairly thick duff surface soil layer existed. This duff layer along with large volumes of downed woody debris were capable of retaining large volumes of water that would otherwise runoff the clay textured surface soil.

Although natural disturbance information is not well documented for the pre-European clay plain forest, the primary disturbance forces were likely wind and fire. Wind storms could easily blow down areas of shallow rooted fir and spruce in the uplands. Ravines were somewhat protected from the wind. The downed conifer trees provided fuel for occasional fires, most likely started by lightening. These fires were seldom severe, and with fairly high moisture conditions in the standing forest, burned through the blow down and than were extinguished by the moist conditions in the adjacent standing forest. Again ravines were very moist and resistant to fire disturbance.

When Europeans arrived they found a dense forest cover, particularly along waterways. Conditions within this dense forest cover inhibited human passage. To them the forest was a hindrance to be overcome.

Initially harvesting the white pine was the focus. Because roads were few and poor at best, waterways were the thoroughfare to move logs to sawmills. Waterways were dammed and large volumes of logs were floated down stream to Lake Superior. The energy and force resulting from this activity drastically effected erosion along waterways. Also, log drives removed most of the large natural woody debris that had been deposited over hundreds of years. Removal of the woody debris deteriorated the structural features of the streams, reducing habitat for organisms and negatively impacting their hydrological character. Evidence of damage caused by log drives is still visible today.

Harvesting was soon followed by the desire to clear land for farming. The relatively stone-free clay soil offered great opportunity for farming. Remaining forest cover in areas to be farmed were removed. This land clearing usually involved burning of the unwanted forest debris.

While it is often thought that the harvesting of white pine is what left the clay plain landscape so barren, it was actually fire that so completely opened up the landscape. Most of these fires were man caused, likely associated with land clearing operations for agriculture. With already large volumes of conifer slash left on the forest from harvesting and land clearing fires were much larger and more intense than natural fires that occurred during pre-European times.

Where land wasn’t farmed, burned over areas offered great opportunity for pioneer species like aspen and paper birch to become established. Conifers did remain on the landscape but due to their flammability much of the cover type was consumed by fire. Most of the remaining conifer cover was likely confined to the ravines.

Harvesting, land clearing for agriculture and fire were the main three man caused disturbances that removed almost all forest cover indicative of pre-European settlement. Of these disturbances fire produced the greatest change. Log drives down streams scarred channels initiating large erosion areas still evident today. Upland retention of rainfall and snowmelt water runoff was substantially reduced. Energy produced by increased runoff flowing through the badly scarred waterways produced high stream erosion rates.

Artificial Drainage
One additional man-caused disturbance that went beyond changing forest cover was changing the shape of the landscape surface itself. Artificial drainage associated with agricultural fields and road infrastructure moves rain and snow-melt water, already rapidly running off the exposed clay soil, at an even faster rate off the uplands. This expedited delivery to streams creates even greater energy available to erode stream banks and adjacent slopes. While impacts from disturbance to the pre-European forest and stabilization of stream riparian areas is slowly occurring with time through natural forest succession, artificial drainage is maintained, and likely has a great impact on modern day flooding of south shore streams.

Summary
Similar summary of these events and conclusions of their impacts on the red clay plain are presented in the 1998 publication "Erosion and Sedimentation in the Nemadji River basin" (NRCS, 1998). Although there are some differences in the landscape character of the Nemadji River basin and part of the clay plain to the east this publication's conclusions and strategies for management are very applicable. The Nemadji River basin study serves as an excellent template for remedial management of the hydrologic conditions in the clay plain in general. Any future work to improve hydrologic conditions in the clay plain should begin with a review of this document.

Michigan

Table 6-17 lists the 12 streams in the Michigan portion of the Lake Superior basin that are not meeting designated uses.

Elevated copper concentrations from copper ore tailings are problems for a number of streams (Hammell Creek, Kearsarge Creek, Scales Creek and Traprock River) in Houghton County. Habitat loss to sedimentation has also been a problem in this watershed. The west and east branches of the Eagle River also have high levels of copper.

Table 6-17 Michigan non-attainment streams in the Lake Superior basin (Michigan Dept. of Environmental Quality 1998)

Stream	Length (km)	Problem	Source
Adventure Creek	1	Macroinvertebrate community rated poor	Obstruction of stream channel resulted in severe erosion and sedimentation
Mineral River	1	Macroinvertebrate community rated poor; total dissolved solids	
Bluff Creek	21	Fish community rated poor.	Sedimentation and bank erosion related to extreme flow fluctuations
Kearsarge Creek	6	Copper; macroinvertebrate	Copper ore tailings

Table 6-17 Michigan non-attainment streams in the Lake Superior basin (Michigan Dept. of Environmental Quality 1998)

Stream	Length (km)	Problem	Source
		community rated poor.	
Scales Creek	418	Copper; macroinvertebrate community rated poor.	Copper ore tailings
St. Louis Creek	1	CSO, bacterial slimes, pathogens.	
Hammell Creek-Osceola Mine Discharge	1	Mercury and copper	Copper ore tailings
Trap Rock River	10	Copper	Copper ore tailings
Eagle River, E. Br.	10	Copper	
Eagle River, W. Br.	4	Copper; macroinvertebrate community rated poor	
Carp River	47	Mercury	
Whetstone Creek	3	Periodic fish kills.	Urban stormwater runoff, severe sedimentation and discharges of suspected toxic substances
Carp Creek	18	Mercury.	

6.1.9 Inland Lakes

The Lake Superior basin has almost 7000 inland lakes, covering over 10,000 square kilometers. These lakes range in size from less than 1 ha to Lake Nipigon at 448,000 ha (Table 6-18). Inland lakes are an important link in the hydrological cycle since much of the water that enters Lake Superior flows through lakes. They contribute to the diversity of aquatic habitats in the basin.

Most lakes are found on the shallow soils of the Precambrian Shield in Ontario and northern Minnesota (Figure 6-44). Another concentration of lakes is in the Presque Ile River watershed in Vilas County Wisconsin and Gogebic County, Michigan.

Secchi depth is a measure of lake transparency, reflecting the amount of suspended material and algae in the water. Secchi measurements are available for over 700 lakes in the basin. Over half the lakes are in the 1 – 3 m Secchi depth range (Figure 6-45). Inland lake transparency is recommended as an indicator of ecosystem health by the Lake Superior Binational Program (1998). Unpolluted lakes show a range of transparencies due to naturally-occurring differences in nutrient availability and turbidity. However, changes in Secchi transparency can indicate a change in the trophic state of a lake due to pollution.

Inland lakes in Ontario and the North Shore area of Minnesota tend to be cool, clear, and low in dissolved solids and nutrients (MPCA 1997). South of Lake Superior, inland lakes tend to be warmer and richer. The number of oligotrophic (nutrient-poor) lakes ranges from 15 to 54 percent in Michigan, Minnesota, and Ontario, but methods of measuring trophic status differ between Ontario and the U.S., and comparisons are difficult (Figure 6-46).

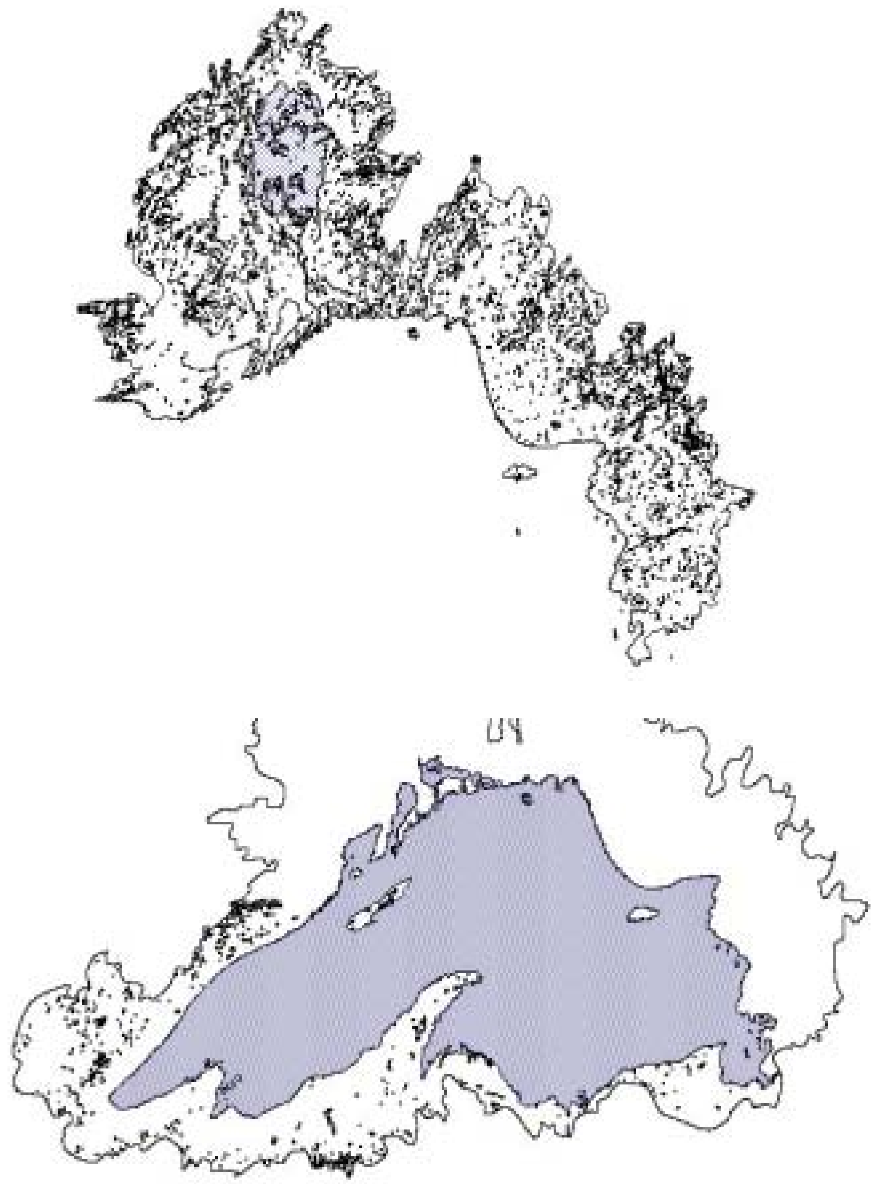
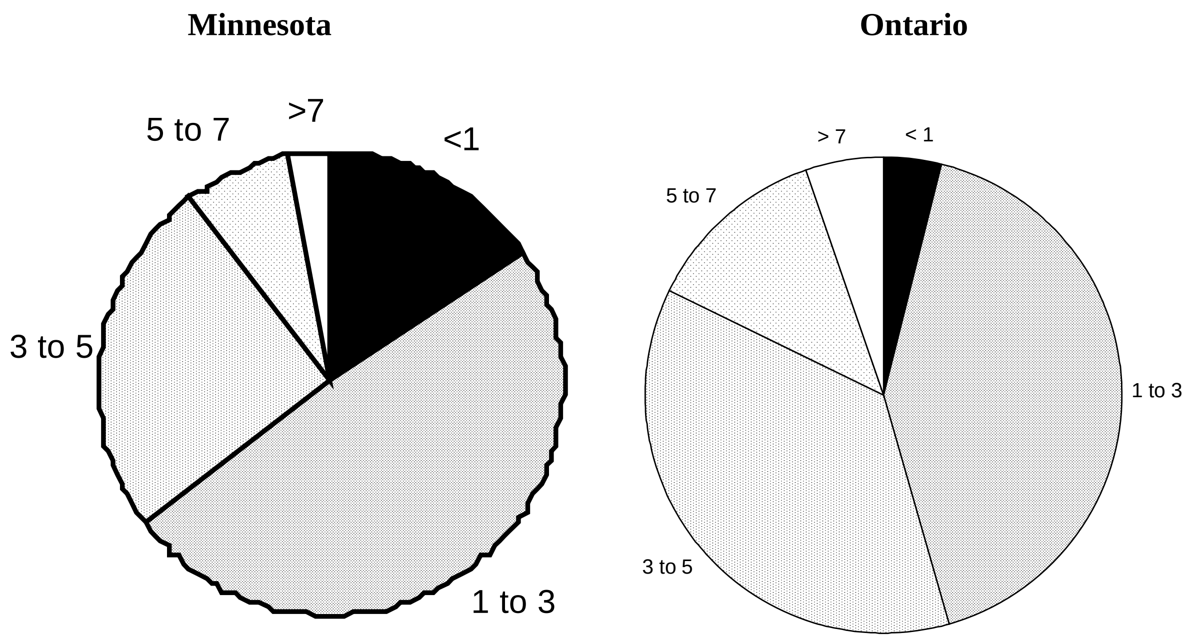


Figure 6-44. Inland Lakes of the Lake Superior basin
(Lake Superior Decision Support Systems and OMNR data)

Figure 6-45. Secchi depth (m) for 1,128 Ontario and 147 Minnesota lakes within the basin (Ontario Ministry of Natural Resources and MPCA Data)



Fish communities in Ontario and Minnesota are dominated by cool and coldwater species (Figure 6-47). Oligotrophic lakes often support lake trout, lake herring and lake whitefish, but are relatively species-poor. About 100 lakes in the Minnesota North Shore support lake trout (Waters 1987). Some lakes in the southern part of the basin provide warmer and more nutrient-rich habitat than Lake Superior. Warmwater species, such as sunfishes and catfishes, dominate the fish community.

Table 6-18 Major Inland Lakes in the Lake Superior Basin

Lake Name	Area (km^2)	Max. Depth (m)	Mean Depth (m)	Littoral Area (%)	Trophic Status*	Secchi Depth (m)
Lake Nipigon, ON	4,481	137	55		Oligotrophic	6.5
Dog Lake (Thunder Bay), ON	148	117	30	29	Oligotrophic	2.5
Onaman Lake, ON	108	19	2	97	Eutrophic	1
White Otter Lake, ON	83	56	22	91	Oligotrophic	4.8
White Lake, ON	59	49	9	54	Eutrophic	2.7
Shebandowan Lake, ON	59	38	8		Oligotrophic	2.9
Lake Gogebic, MI	52					
Dog Lake, (Wawa) ON	52	75				4.4
Black Sturgeon Lake, ON	48	49	12	23	Oligotrophic	2.5
Esnagi Lake, ON	46	22	5	47	Eutrophic	3.7
Windermere Lake, ON	38	30	8		Oligotrophic	4.8
Wabatongushi Lake, ON	38	53	7	59	Eutrophic	2.9
Obonga Lake, ON	36	72	17		Oligotrophic	3
Muskeg Lake, ON	35	12	5	66	Eutrophic	2
Island Reservoir, MN	34	22	-		Eutrophic	2
Arrow Lake, ON	33	55	18	23	Oligotrophic	4.7
Manitowik Lake, ON	31	119	38	19	Oligotrophic	3.7
McKay Lake, ON	31	49	9	62	Eutrophic	4
Greenwater Lake, ON	31	55	18	14	Oligotrophic	4
Whitefish Lake (Th. Bay), ON	30	6	2	100	Eutrophic	3
Forgan Lake, ON	30	44	13	35	Mesotrophic	4
Cedar Lake, ON	29	15	6	100	Eutrophic	2.1
Cliff Lake, ON	27	34	9	50	Eutrophic	4.3
Kagiano Lake, ON	24					2
Barbara Lake, ON	24	56	10		Oligotrophic	3
Kashabowie Lake, ON	23	35	7	58	Oligotrophic	2.6
Whiteface Reservoir, MN	23	10			Eutrophic	1.2
Holinshead Lake, ON	23	17	5		Oligotrophic	2
Athelstane Lake, ON	18	33	9		Oligotrophic	3.4
Garden Lake, ON	18	22	7		Oligotrophic	2
Boulder Lake, MN	18	29		74		2.1
Wabinosh Lake, ON	18	39	11		Oligotrophic	5
Whitefish Lake (Wawa), ON	18	55	15	33	Oligotrophic	3.1
Wildgoose Lake, ON	17	16	4		Eutrophic	4
Roslyn Lake, ON	17	45	10		Oligotrophic	4
Loch Lomond, ON	17	71	21		Oligotrophic	4

Table 6-18 Major Inland Lakes in the Lake Superior Basin

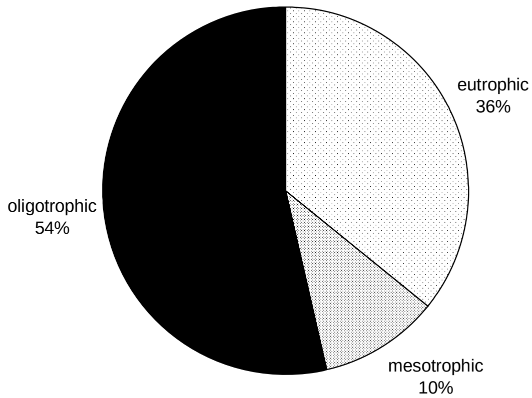
Lake Name	Area (km^2)	Max. Depth (m)	Mean Depth (m)	Littoral Area (%)	Trophic Status*	Secchi Depth (m)
Brule Lake, MN	17	18		34	Oligotrophic	4.9
Helen Lake, ON	16	61	13		Mesotrophic	3

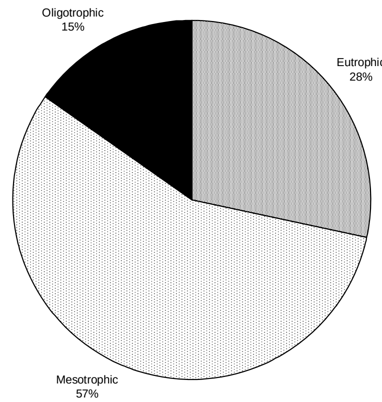
*Trophic status for Ontario lakes is based on morphoedaphic Index (MEI). MEI values between 6 and 7 are mesotrophic, higher are eutrophic, lower are oligotrophic (Leach and Herron 1996). Trophic status for U.S. lakes are determined using the Carlson method.

Table 6-19 Inland lakes in the Lake Superior basin

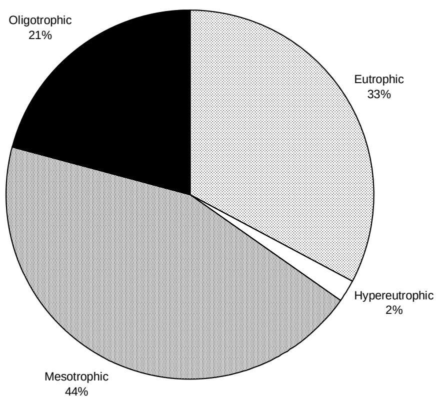
(derived from OMNR and NRRI data)

	n	% > 10 ha	Shoreline Length (km)	Total Area (km^2)	Mean Area (km^2)
Ontario					
Lakes and Reservoirs	5049	95	27019	9277	2.0
Michigan					
Lakes	668	67	1842	361	0.5
Reservoirs	36	78	248	91	2.5
Minnesota					
Lakes	873	71	2357	375	0.4
Reservoirs	38	76	412	101	2.7
Wisconsin					
Lakes	272	70	683	104	0.4
Reservoirs	9	78	45	12	1.4





Ontario **Michigan**



Minnesota

Figure 6-46. Trophic status of inland lakes in the Lake Superior basin

(a) Ontario (n= 516), (b) Michigan (n = 78) (c) Minnesota (n = 208) (data from Ontario Ministry of Natural Resources, Michigan Dept. of Environmental Quality, and Minnesota Pollution Control Agency data data)

Ontario

Ontario lake survey data are available from 1,251 lakes within the basin, but there are thousands of unsurveyed lakes. Surveyed lakes tend to be large, accessible and support sport fishes. Much of the lake survey data is over 20 years old.

Two lakes in the basin, Lim and Mose lakes, are severely degraded by mine effluent (OME 1992). Numerous other lakes have fish consumption advisories – primarily due to mercury levels. Ontario does not have an on-going lake water quality program.

Dams have altered water level regimes on many of the larger inland lakes. Dams were built to improve navigation or for historical log drives and many of these dams persist today. Increased water levels resulted in flooding the original shoreline and disruption of the natural flooding-drawdown cycle.

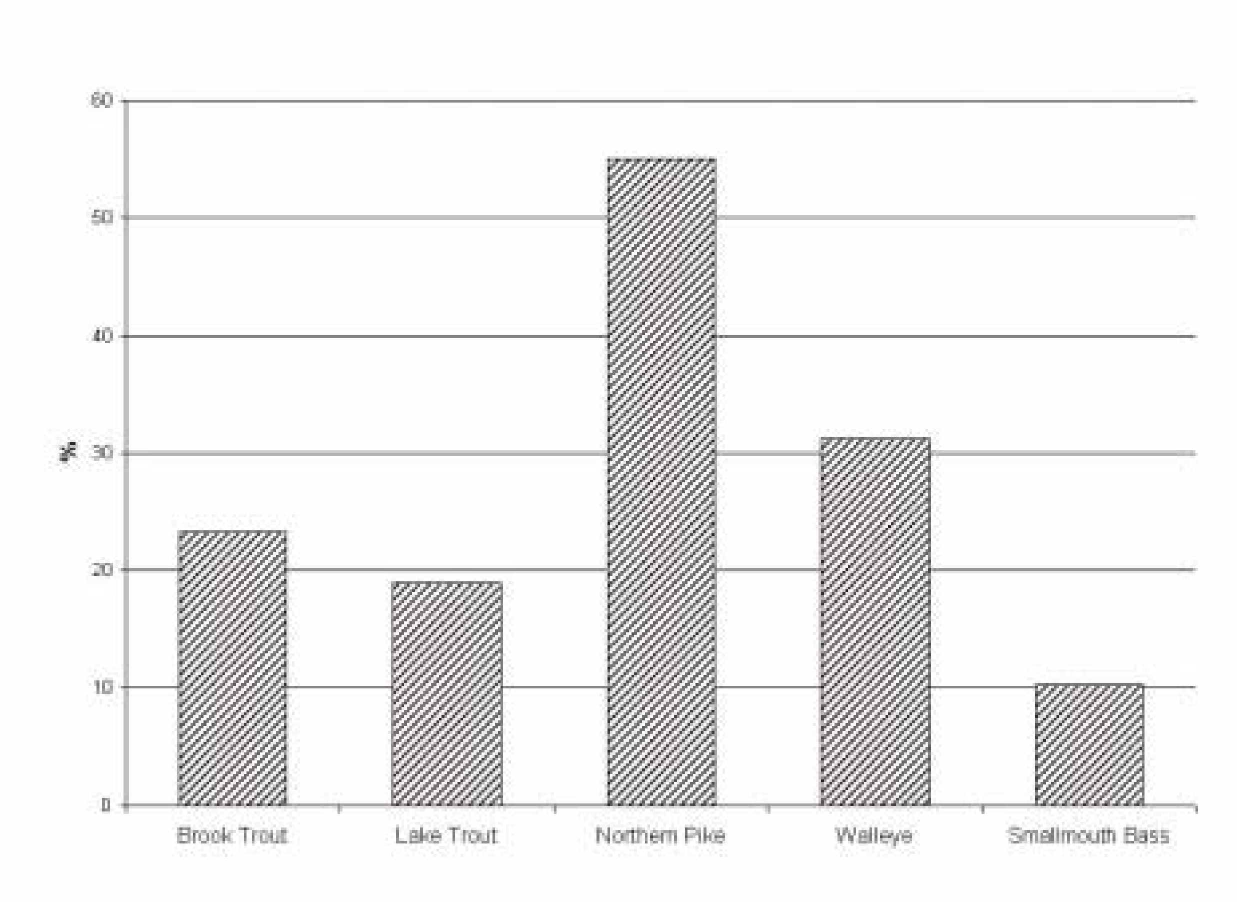


Figure 6-47. Frequency of occurrence of major sport fish species in 612 Ontario lakes in the Lake Superior basin
(**Ontario Ministry of Natural Resources data)**

Most inland lakes in Ontario are within forest management units where logging takes place. Potential impacts of logging and associated road construction include increased sedimentation, increased water temperatures, changes in water yield and availability of woody debris (OMNR 1988). Provincial policy requires reserves of uncut forest to be left around lakes. Reserve widths depending on shoreline slope and fisheries values (wider for cold water lakes and steeper slopes). A pilot study investigating the habitat impacts of logging on lakes is underway (Steedman personal communication), but widespread monitoring is not done.

Wisconsin

Most lakes in the Wisconsin basin have basic descriptive data. A document summarizing the status of inland lakes in the Lake Superior basin is in preparation (Turville-Heitz 1999).

Twenty six lakes in Wisconsin are listed as having "Impaired Waters" (Turville-Heitz 1999), all related to mercury levels in fish (Table 6-20).

Five Wisconsin lakes in the basin were identified as priority sites from a biodiversity perspective (Epstein and others 1997). These are Anodanta Lake, Bad River Slough, Hoodoo Lake, Rush Lake, and Smith Lake. Most of these lakes have rich invertebrate communities or support rare invertebrate species.

Table 6-20 Wisconsin lakes in the Lake Superior basin with impaired waters (Turville-Heitz 1999)

Lake	Problem
Amnicon Lake	Mercury/fish advisory/atmospheric deposition
Annabelle Lake	"
Bear Lake	"
Bladder Lake	"
Cisco Lake	"
Diamond Lake	"
English Lake	"
Forest Lake	"
Galilee Lake	"
Gile Flowage	"
Island Lake	"
Long Lake	"
Long Lake	"
Lynx Lake	"
Mineral Lake	"
Oxbow Lake	"
Palmer Lake	"

Table 6-20 Wisconsin lakes in the Lake Superior basin with impaired waters (Turville-Heitz 1999)

Lake	Problem
Perch Lake	“
Pike Chain of Lakes	“
Potter Lake	“
Siskiwit Lake	“
Spider Lake	“
Spillerberg Lake	“
Tahkodah Lake	“
Three Lake	“
West Twin Lake	“

Michigan

Ten lakes in the basin are listed as “non-attainment”, mostly due to fish consumption advisories for mercury (Table 6-21). Torch Lake, in Houghton County, was the receiving water for copper ore tailings, and other contaminants. Sediments have high levels of arsenic, copper and other metals and benthic invertebrate communities are impaired (MDEQ 1998).

Table 6-21 Michigan non-attainment lakes in the Lake Superior basin (Michigan Dept. of Environmental Quality 1998)

Lake	Problem
Chaney Lake	FCA-mercury
Marion Lake	Mercury Lake
Langford Lake	FCA – mercury
Six Mile Lake	Mercury Lake
Torch Lake	Macroinvertebrate community rated poor; WQS exceedances for copper
Perch Lake	Mercury Lake
Lake Independence	Mercury Lake
Deer Lake	FCA-mercury
Nawakwa Lake	Mercury Lake
Pike Lake	Mercury Lake

Minnesota

There are five major hydroelectric dams on the St. Louis River system creating two of the largest impoundments in the basin: Island Reservoir and Whiteface Reservoir (MPCA 1996). These are headwater reservoirs that store water during the spring run off and release it to augment low flows at other times of the year. Other impoundments (Two Rivers Reservoir and Whitewater Reservoir) are used to for mine processing water and recreation.

Water quality monitoring in Minnesota lakes is done by the Minnesota Pollution Control Agency. Emphasis has shifted recently, away from point-source influenced lakes to volunteer monitoring (approximately 30 lakes in the basin – secchi depth, recreational suitability) and reference lake monitoring (water quality, land use in the watershed) (MPCA 1997).

Water quality is generally quite good (MPCA 1996). Thompson and Fond du Lac reservoirs have significantly contaminated sediments (MPCA 1996). 94 percent of inland lakes tested (137/146) have fish consumption advisories, due to mercury levels (n = 133), PCB levels (n = 1) or both (n = 3) (MPCA 1996).

Minnesota, Michigan and Wisconsin have volunteer lake monitoring programs (Lake Superior Binational Program 1998).

Summary

The status of habitat in inland lakes in the Lake Superior basin is generally very good. Gross habitat impairment from point sources has occurred in only a few lakes. More subtle changes in lake habitat, such as eutrophication, sedimentation and warming, due to land use changes are more difficult to detect and measure, as are the impacts of non-point source pollutants.

6.1.10 Rare and Declining Species

The species discussed in this section are considered to be rare or declining in at least one of the states/provinces in the basin. Species can be listed at the federal, provincial, or state levels.

The U.S. federal categories are as follows:

> **Endangered** - The classification provided to an animal or plant in danger of extinction within the foreseeable future throughout all or a significant portion of its range.
>
> **Threatened** - The classification provided to an animal or plant likely to become endangered within the foreseeable future throughout all or a significant portion of its range.
>
> **Species of Concern** - "Species of concern" is an informal term that refers to those species which might be in need of concentrated conservation actions. Such conservation actions vary depending on the health of the populations and degree and types of threats. At one extreme, there may only need to be periodic monitoring of populations and threats to the species and its habitat. At the other extreme, a species may need to be listed as a Federal threatened or endangered species. Species of concern receive no legal protection and the use of the term does not necessarily mean that the species will eventually be proposed for listing as a threatened or endangered species.

The Canadian federal categories are:

- **Endangered:** A species facing imminent extirpation or extinction.
- **Threatened:** A species likely to become endangered if limiting factors are not reversed.
- **Vulnerable :** A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.

Ontario, Minnesota, Wisconsin, and Michigan have slightly differing definitions for the state / provincial level listings, but are similar in intent to the federal listings.

6.1.10.1 Bald Eagle

The bald eagle is threatened in Michigan. A state-wide survey is conducted each year to monitor breeding success. The state goal is to have 300 nesting pairs. Between 1976 and 1999, a total of 130 different breeding areas were active within the Baxin, including Isle Royale (not all are occupied in any given year). The number of breeding areas has increased over the last 20 years. In 1999, 89 breeding areas were occupied by adult pairs (Dave Best personal communication). The Michigan Department of Natural Resources also conducts mid-winter bald eagle surveys. In 1999, there were 235 eagles reported in the Upper Peninsula. The status of eagle habitat in the basin appears to be stable (Ray Rustem personal communication).

Since the ban of DDT in the late 1960's, Bald Eagle numbers have increased throughout their range. In 1999 they were removed from the U.S. Endangered Species List.

Within the Lake Superior basin, eagle numbers appear to have followed the same pattern of decline and recovery, but little specific data are available. Reproductive rates of eagles nesting along the Lake Superior shoreline are significantly lower than those nesting on inland lakes (1.0 vs. 1.3 young per active territory) (Dykstra and others 1998). Depressed reproduction rate was likely caused by low food availability.

Nesting habitat for Bald Eagles includes trees that at are large enough to hold their massive nests. Red and white pine supercanopy trees are preferred in Minnesota (Coffin and Phannmuller 1988) Many of these nests are close to lakes or rivers, areas where the eagles scavenge for fish.

Figure 6-48 shows an assessment of bald eagle nesting habitat based on percentage of forested area and proximity to the shoreline, potential human disturbance, shoreline irregularity, available foraging habitat, and availablity of perching and nesting trees (Bowerman 1993).

Wisconsin

About 1500 bald eagle pairs nest in Minnesota and Wisconsin, but less than 5 percent of these are along the Lake Superior coast (Bill Bowerman, personal communication). The number of occupied territories along the Wisconsin Lake Superior coastline tripled between 1983 and 1991 (Meyer 1992).

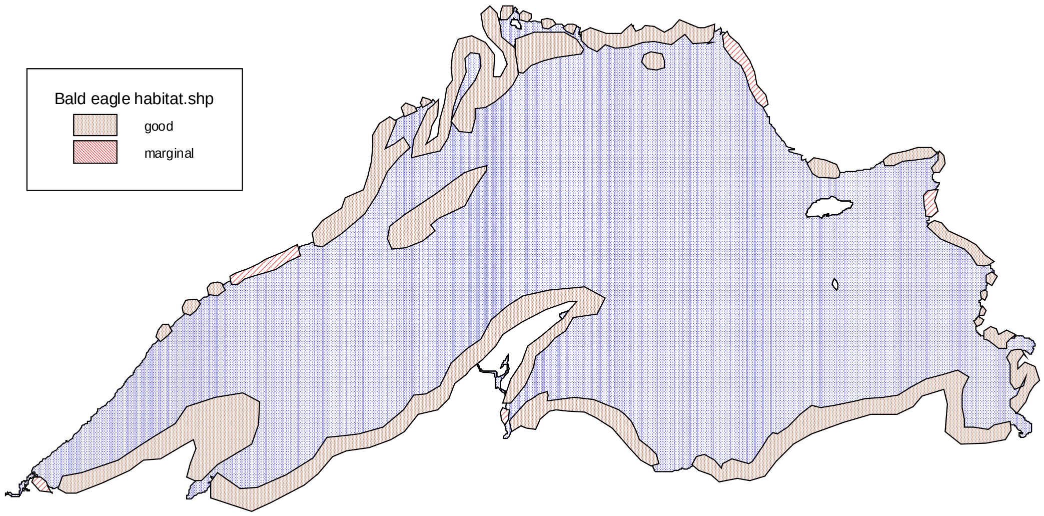


Figure 6-48. Potential bald eagle nesting habitat within 1.6 km of Lake Superior Unshaded areas are considered unsuitable (Bowerman 1993)

Nesting habit is considered good to excellent within the Lake Superior basin. Housing construction is occurring at a record pace along lakeshores and riparian lands in northern Wisconsin and it is not known what this threat has on eagles nesting. Contaminant levels have dramatically declined in recent years and is no longer considered a threat to reproduction. Productivity of nesting eagles along the Lake Superior coast fluctuates from year to year depending on ice conditions and prey availability (Mike Meyer, Wisconsin DNR personal communication).

On the Apostle Islands, there has been a fairly stable population of about five pairs for the last few years (Julie Van Stappen, Apostle Islands N.L. per. comm.). Food shortage appears to limit population growth since there are many adequate nesting trees available and blood analysis indicates that contaminants are probably not impairing survivorship or reproduction. Spring ice packs restrict access to fish and the absence of deer on the islands limits late winter food availability.

Bald Eagles were delisted in Wisconsin in 1998. There have been annual surveys since 1985 and the future of these surveys is in doubt due to declining funds from the Adopt an Eagle Nest Fund.

Minnesota

The Minnesota population of Bald Eagles has increased dramatically since the 1970's and is now estimated at about 700 pairs. The last statewide survey was conducted in 1995, the same year that the birds were delisted. Based on current information (1999) in the Minnesota Heritage data, there are 41 eagle nests located in the Lake Superior basin. Most of these nests are in the interior away from Lake Superior (Maya Hamady, personal communication).

Habitat availability is probably the main factor limiting the number of eagles. Lake Superior probably offers poor foraging opportunities compared to inland lakes and the landscapes that drain into Lake Superior lack inland lakes.

Michigan

The bald eagle is threatened in Michigan. A state-wide survey is conducted each year to monitor breeding success. The State goal is to have 300 nesting pairs. The 1997 survey located 298 nests, of which 166 nest were in the Upper Peninsula. An estimate for the Lake Superior basin was not available and will be included in the final habitat report. The Michigan Department of Natural Resources also conducts mid-winter bald eagle surveys. In 1999, there were 235 eagles reported in the Upper Peninsula. The status of eagle habitat in the basin appears to be stable (Ray Rustem, Supervisor of the Natural Heritage Unit, Wildlife Division, MI DNR).

Ontario

In Ontario, bald eagles are Endangered. The number of eagle nests along the north shore has been fairly stable for the last few years, although new nests are established as old ones are abandoned (Foster and others 1999).

In the Thunder Bay District, most of the larger inland lakes have established nesting pairs and there are a few nests along the Lake Superior coastline. There have been no recent surveys, but the population probably has not changed in the past few years (Steve Scholton, Thunder Bay District OMNR, personal communication).

The Lake Superior shore between Black Bay and Pukaskwa Park appears to consists of good habitat. Population has been fairly stable with 15 – 16 nests. Spring runs of trout, salmon and suckers are common and food supply should not be a limiting factor. Lake Nipigon has not been surveyed in a few years, but numbers have probably not changed dramatically in recent decades (Rosemary Hartley, Nipigon District OMNR, personal communication).

Seven active nests are in the White River to Montreal River portion of the watershed. Numbers appear to be growing and habitat does not appear to be a limiting factor (Joel Cooper Wawa District OMNR, personal communication).

The shoreline south of the Montreal River to Sault Ste. Marie has fewer than ten active nests. Habitat is adequate and there is room for more pairs (Jim Saunders, Sault Ste. Marie District ONMR, personal communication).

Eagle nest sites are recognised in timber management and guidelines for their protection are applied in Ontario.

6.1.10.2 Peregrine Falcon

Peregrine falcon populations declined across North America due nesting failure resulting from to bioaccumulation of DDT and its metabolites. They disappeared as a nesting species from most of the Lake Superior basin by the mid 1960's.

Following the ban of DDT, efforts were initiated to re-establish peregrine falcons as a breeding species within the Lake Superior basin. Between 1988 and 1996, Minnesota hacked 40 young peregrines on the North Shore, Michigan released 50 young birds on Isle Royale, and 46 bird in the Upper Peninsula. Ontario hacked 87 birds in the Thunder Bay area and 38 near Sault Ste Marie (Bud Tordoff, Ted Armstrong, personal communication). These efforts have succeeded in establishing nesting pairs (Table 6-22). In the Lake Superior basin, 90 young peregrines were banded in Ontario and 59 young in Minnesota between 1996-1999.

The peregrine falcon was removed from the United States Endangered Species List in 1999. Michigan and Wisconsin list peregrines as Endangered, while Minnesota lists peregrines as Threatened. In Canada, peregrines are classified as Threatened at the federal level, but are considered Endangered in Ontario.

Peregrines nest on cliff ledges, often adjacent to water, but inland sites are also used. Man-made structures such as buildings, bridges, smokestacks, and quarries, are sometimes used. The best peregrine habitat in the Lake Superior basin is associated with the numerous large cliffs between the Pigeon River and the Nipigon River in Ontario (Ratcliff 1997, 1998, 1999). Almost half of the nests in the basin are in this area.

Current and potential peregrine territories are shown in Figure 6-49. "Potential" territories include historical nest sites that are not currently used and other cliffs which have been surveyed and assessed as being suitable (Ratcliff 1997, 1998, 1999; Bud Tordoff, personal communication). Due to the large amount of potential habitat available, and inaccessibility of most of this area, the estimate is a minimum number.

Overall, the status of peregrine falcon habitat is stable or increasing. Manmade structures increase the number of potential nest site in the Lake Superior basin over historical levels.

Ontario

In 1998, there were 17 known territories occupied by pairs and three territories held by a single birds and in 1999, 12 territorial pairs and six single bird territories were located in the Lake Superior basin. In addition, there are at least six confirmed and suspected historical sites that probably could support pairs (Ratcliff, 1997, 1998, 1999) (Table 6-22).

Minnesota

Historically, peregrines nested on five cliff sites along the northshore. As of 1998, there were eight pairs of peregrines along the North Shore of which, two used bridges within the city of Duluth and two nests were on mining structures (Bud Tordoff personal communication). There is potential for four more cliff nesting sites (Bud Tordoff, personal communication). Annual surveys are conducted throughout Minnesota checking both cliff sites and man-made structures.

Wisconsin

The small cliffs within the Wisconsin portion of the Lake Superior basin are not suitable for breeding peregrines. Except for man-made structures, habitat is very limited (Bud Tordoff and Sumner Matteson personal communication). There are no historical records for this area and any future nesting sites will probably be on man-made structures. Wisconsin conducts annual surveys for peregrines, and to date all nesting sites have been on man-made structures outside the Lake Superior basin.

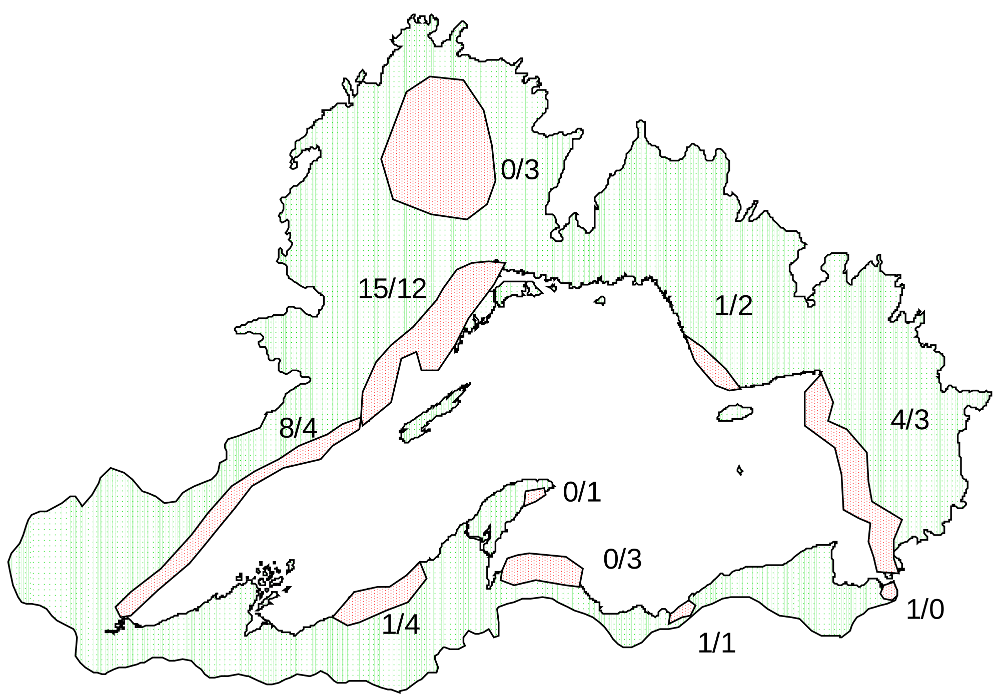


Figure 6-49. Peregrine Falcon Habitat in the Lake Superior basin
Numbers of current and additional potential territories are given (current number/potential number)

Michigan

Historically, peregrines nested at 13 cliff sites in the Upper Peninsula. There are four known cliff sites where peregrines nested during the 1990's (Bud Tordoff, personal communication), and in 1999 birds nested at two of these sites (Joe Rodgers, personal communication). A pair was also established but unsuccessful at the International Bridge at Sault Ste. Marie. Annual surveys for peregrines are conducted. There is good potential habitat it the Upper Peninsula (Joe Rodgers) (Table 6-22).

6.1.10.3 Piping Plover

Piping plover is classified as Endangered in Michigan, Wisconsin, Minnesota and Ontario and federally in both Canada and the U.S. (Great Lakes Population).

In the Great Lakes area, these birds historically nested on sandy and gravel beaches and sparsely-vegetated shorelines with gravel or pebbly mud substrate. At Duluth, they nested on dredge-spoil islands (Coffin and Pfannmuller 1988). Beaches separated from the tree line by a wide dune system or slough offer the best habitat and wide beaches provide better habitat than narrow beaches (Lambert and Ratcliff 1979).

Table 6-22 Current and potential peregrine falcon territories in the Lake Superior basin

Location	Current Territories	Other Potential Territories
Ontario		
Pigeon River to Nipigon	15	12
Lake Nipigon	0	3
Pukaskwa to Michipicoten	1	2
Lake Superior P.P. to Sault Ste. Marie	4	3
Minnesota		
Northshore	6	4
Duluth	2	-
Wisconsin	-	-
Michigan		
Sault Ste. Marie	1	0
Porcupine Hills/Bergland	1	4
Pictured Rocks/ Grand Island	1	1
Bete Grise Bay	0	1
Huron Mountains/Champion	0	3
Total	**31**	**33**

Since the 1960s, piping plover populations have declined precipitously. Threats to habitat include high water levels (mid-summer storms), recreational uses, and all-terrain vehicles on beaches. Additional threats to plovers include increased gull populations and free running dogs on beaches. The quantity and quality of beach habitat is dynamic and influenced by fall and winter storms that erode and deposit sand and set back vegetation succession.

Ontario

There have been no documented reports of piping plovers nesting along the Lake Superior shoreline, although there is potential habitat Caribou Island (good), Agawa Bay (marginal) and Beaver Rock (marginal) (Heyens 1996). Also, the mouth of the Pic River should be considered as good habitat. There are no annual surveys for piping plovers on Lake Superior.

Minnesota

The Minnesota north shore has very limited Piping Plover habitat. Historically they nested at the Duluth Harbour on industrial lands; with six to eight pairs during the early 1970s and three pairs in 1985. However, development pressures, recreational use, increased Ring-billed Gull populations, and lack of management has limited this area for breeding (Coffin and Pfannmuller 1988). No plovers have nested here in the 1990s (Katie Haws, personal communication).

Wisconsin

Historically piping plovers nested in the 1950s at Barkers Island and Wisconsin Point in the Duluth - Superior Harbour. Piping Plovers did not nest along Lake Superior coastline for many years, but in 1998, one pair was successful (four young) at Long Island/Chequamegon Point (Sumner Matteson, personal communication). In 1999, one nesting pair and four other adults were observed here. The pair laid four eggs, hatched two young, but both young were killed by a mammalian predator. Surveys have been conducted each year since 1974. The habitat at Long Island has expanded due to lower water levels and the area could support 15 - 20 pairs (Sumner Matteson, personal communication).

Michigan

Michigan has most of the piping plover habitat on Lake Superior. There is excellent habitat in Luce, Alger and Chippewa Counties. Another site at Pictured Rocks National Seashore has marginal habitat.

The 1998 survey located seven nests at four sites: four nests at two sites near Grand Marais (Alger County), one nest at Vermillion (Luce County) and two nests at Weatherhogs Beach, (Chippewa County (Hinshaw 1998). Two historical nesting areas were surveyed with no nests found : Twelve Mile Beach, Pictured Rocks National Lakeshore, Alger Co. and Lake Superior State Forest Campground beach, Luce Co. The number of pairs is similar to those found in a 1979 survey (Lambert and Ratcliff 1979) (Table 6-23).

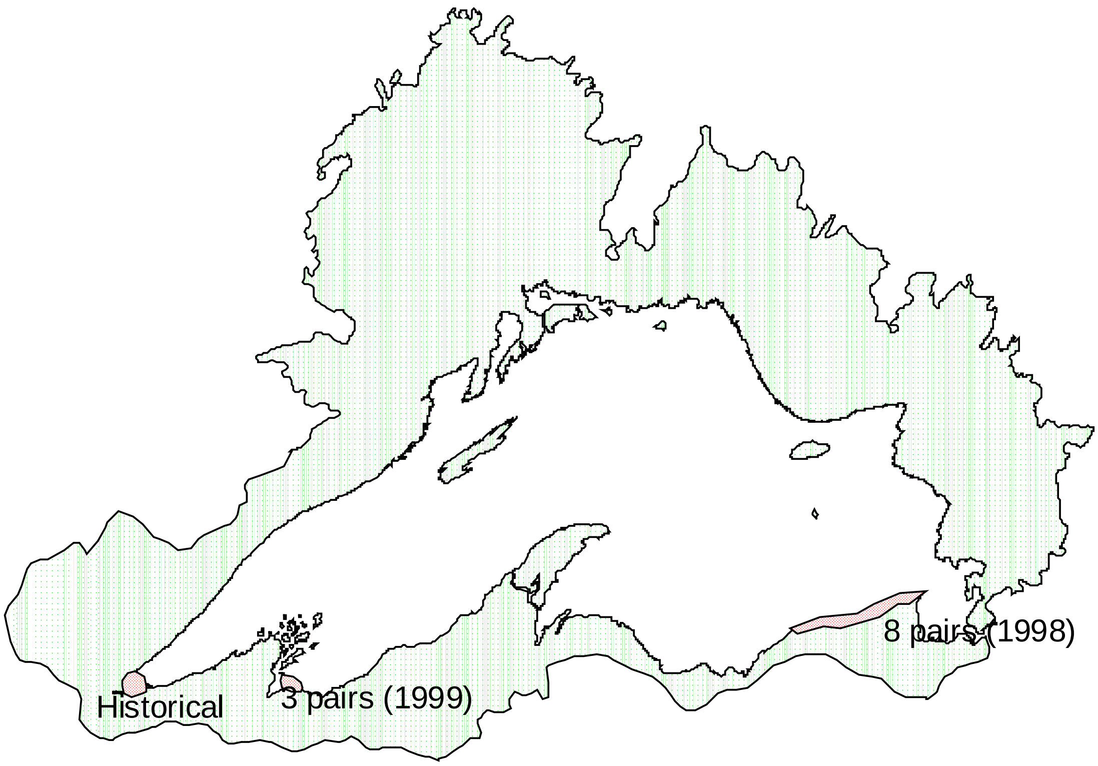


Figure 6-50. Piping plover habitat in the Lake Superior basin

Table 6-23 Piping plover survey results, Michigan (Lambert and Ratcliff 1979, Hinshaw 1998)

Location	Number of sites		Nests	
	1979	1998	1979	1998
Luce County	5	1	4	1
Alger County	1	2	3	4
Chippewa Co.	5	1	3	2

Habitat for plovers in Michigan at Vermillion is shifting eastward as vegetation encroaches on more westerly areas. The eastern portions of the beach are becoming narrower and more vegetated as well, resulting in a shift toward less suitable nesting habitat at this site. East of the Vermillion site, Weatherhogs Beach is widening and use of this area by plovers is increasing. Human disturbance of plover nests at Weatherhogs is more difficult to restrict than at Vermillion where the Whitefish Point Bird Observatory staff can restrict access and more closely monitor use of the beach. Enhancing habitat at Vermillion may be needed to retain it as a nesting area.

6.1.10.4 Common Tern and Caspian Tern

Common terns *(Sterna hirundo*) are Endangered in Wisconsin, Threatened in Michigan, Special Concern in Minnesota and unlisted in Ontario (Matteson 1988). Common terns nest at the St. Louis River estuary at the Duluth-Superior Harbor in Minnesota/Wisconsin. This colony declined 63 percent between 1977 to 1987 (Matteson 1988). In Wisconsin, there are 29 colony records on Lake Superior from the period between 1946 and 1987, most of these since the 1950's (Matteson 1988). In Michigan, common terns formerly nested along the Lake Superior coast in Chippewa County, but there are no recent nestings here (Hyde 1997). Common terns nest at several locations in the Ontario portion of the basin, but the north shore of Lake Superior constitutes a conspicuous distribution gap in the province (Blokpoel 1987). Low productivity of the lakes in the boreal shield in Ontario may be a limiting factor.

Caspian terns (*Sterna caspia*) are Endangered in Wisconsin, Threatened in Michigan and Vulnerable in Canada. This species was probably never common on Lake Superior (Hyde 1996). They nest at several locations in the Wisconsin part of the basin (WI DNR 1999a), but apparently don't nest in Minnesota. In Michigan, Caspian terns nest in several of the counties bordering Lake Superior, but are not known to nest within the basin itself (Hyde 1996). They are not known to nest in the Ontario basin (Austen and others 1994).

Chemical contamination, harvest for the millinery trade, and gull displacement contributed to the decline of these species. Important habitat includes small, sparsely vegetated islands or peninsulas for nesting. They will nest on man-made islands. Habitat related concerns include human disturbance at nesting sites, destruction of nesting habitat, and encroaching dense vegetation on nest sites. Rising water levels can flood nests and decrease available nesting habitat (Matteson 1988).

The objectives of the Wisconsin common tern recovery program are protecting nesting sites and establishing new colonies, population monitoring, evaluating chemical and habitat conditions and enhancing awareness (Matteson 1988).

6.1.10.5 Gray Wolf

The gray wolf was formerly distributed throughout the Lake Superior basin, but declined after the early 1800's due to extermination efforts in both Canada and the U.S. Wolf populations never declined to low levels in Ontario, but were extirpated in most of the U.S. portion of the basin by the early 1970s. Remnant populations persisted in northern Minnesota and on Isle Royale. Wolves were listed federally as Endangered in the US in 1967, offering them full protection. Wolf numbers and range increased in Minnesota and they repopulated Wisconsin and the Upper Peninsula of Michigan through immigration from Ontario and Minnesota. All three states now have breeding populations (Figure 6-51). A proposal to remove wolves from the federally Endangered list in the Great Lake States by the year 2001 is being considered by the U.S. Department of the Interior.

Wolf habitat consists of a relatively large land area with an adequate prey base. Major prey species are white-tailed deer in the southern part of the basin and moose in the north. Beaver and small mammals are important summer food. Habitat management to maintain or improve habitat for moose and deer is undertaken in all of the states and Ontario, mainly through timber management. Timber management can improve habitat for deer and moose and therefore have a positive effect on wolves by creating interspersion of mature forest with younger successional forest (Michigan Gray Wolf Recovery Team 1997, Wisconsin Wolf Advisory Committee 1999).

Wolves are most successful where there is limited human access (Michigan Gray Wolf Recovery Team 1997, Wisconsin Wolf Advisory Committee 1999). Road densities greater than 0.6 km / km^2 have been implicated in wolf declines due to collisions with vehicles and access by hunters and trappers. On the other hand, in areas of deep snow in Ontario, ploughed roads and packed snowmobile trails may make it easier for wolves to find and kill prey. Wolves can tolerate greater road density where humans don't kill or harass wolves (Michigan Gray Wolf Recovery Team 1997).

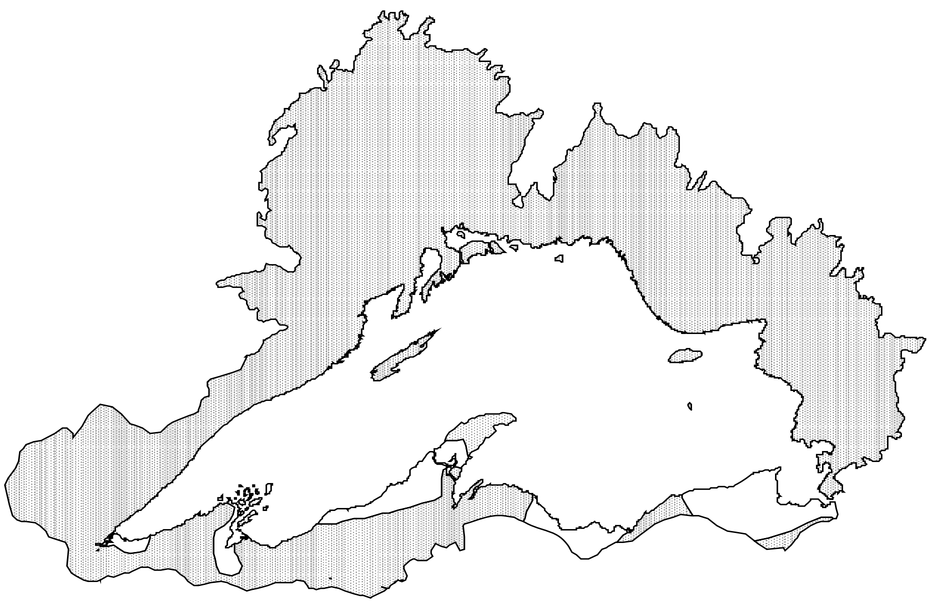


Figure 6-51. Wolf range in the Lake Superior basin C. 1997 (Michigan Gray Wolf Recovery Team 1997, Wydeven 1998, Coffin and Pfannumller 1988, Dobbyn 1994)

Human disturbance at den and rendezvous sites can cause abandonment of these areas. The area required for protection from disturbance has been estimated at approximately 0.05 percent of the pack's territory (13 ha for an average home range of 259 km^2) (Michigan Gray Wolf Recovery Team 1997).

Habitat corridors linking wolf populations may be important to allow wolves to move through landscapes fragmented by human activities (Michigan Gray Wolf Recovery Team 1997).

Wisconsin

Wolves returned to Wisconsin in the mid-1970s, and in 1975 was listed as Endangered. Management and recovery plans introduced in 1989 set goals of a population of 80 or more animals for more than three consecutive years (Wisconsin Wolf Advisory Committee 1999). In 1999, the wolf population reached 197 animals and had been at 80 or more animals since 1995. The Wisconsin Department of Natural Resources has now reclassified wolves as Threatened and is working on a management plan that will eventually delist the species. This plan would delist the wolf to a non-game species when the population reaches 250 or more animals across the state outside of First Nations Lands. A management goal of 350 is recommended.

Since 1979, the State has been monitoring the wolf population by radiocollaring one or two members of each pack. This method has been the most precise method of monitoring the population. Other survey methods include snow tracking and summer howling surveys.

Wolf habitat in Wisconsin has been assessed as primary or secondary (Mladenoff and others 1995). Based on computer models, primary habitat represents areas with a 50 percent or greater chance of supporting a wolf pack and secondary habitat represents areas with a 10 to 50 percent chance of supporting a wolf pack. Most of the primary and secondary habitat is in the northern third of the State, including much of the Lake Superior basin (Wisconsin Wolf Advisory Committee 1999).

Michigan

The Gray Wolf is considered Endangered in Michigan. Wolf populations have recovered from near extinction in the mid 1970s to at least 174 animals in 30 or more packs in 1998 - 99. This compares to 140 wolves located in 1997-98. In 1991, wolves reproduced in Michigan (other than on Isle Royale) for the first time in 40 years. All of the wolf packs are located in the Upper Peninsula (including much of the Lake Superior basin) and Isle Royale.

Monitoring for wolves is conducted by the Department of Natural Resources by using radio telemetry and snow track counts. There has also been a continuous monitoring program of wolves on Isle Royale since 1958. Two wolves first arrived on the island in the late 1940s and the population of wolves is dependant on the local moose population. As moose numbers fluctuate (500 - 2500) so have the wolf numbers fluctuated between 12 and 50 animals. Habitat supply analysis suggests that the Upper Peninsula could support over 800 wolves (Mladenoff and others 1995).

The Michigan Recovery Plan for the Gray Wolf will consider the animal recovered when there is a winter population of 200 animals for five consecutive years. At that time the wolf will be recommended for removal from the Michigan Endangered Species List.

Minnesota

In 1978, Minnesota reclassified the Gray Wolf from Endangered to Threatened and plans to delist the animal in 2000. The 1978 Grey Wolf Recover Plan set a population goal of 1,251 to 1,400 wolves by the year 2000. This goal was achieved when a statewide survey in 1989 estimated the population at 1,550 to 1,750 animals. Surveys estimate the population to be about 2,450 animals in winter of 1998/99 (Mike Don Carlos personal communication).

A wolf management group of 35 groups and individuals has been working on a revised plan for wolf management in Minnesota. This management plan has been produced but the state has not implemented the plan.

In 1999, there were four projects using radio collars to monitor wolves in the state. The Department of Natural Resources also conducts winter snow tracking surveys.

Suitable habitat is located throughout most of the Lake Superior basin in Minnesota (Hazard 1982), but a population estimate for the basin is not available.

Ontario

In Ontario, the gray wolf is classified as a furbearer. Although there has been no effort to estimate the total number of animals in the province, wolves are considered to be common and their range encompasses the Lake Superior basin (Dobbyn 1994).

There have been two recent studies on wolf habitat use and population dynamics within the Lake Superior basin. In 1994, Pukaskwa National Park initiated a six-year predator-prey research initiative called “The P5 Project”. This project investigated the predator-prey dynamics and landscape change in the Greater Puksakwa Ecosystem. Twenty-seven wolves were radio-collared and data was collected on prey base, home ranges and territories. Habitat analysis was also investigated but most of the data collected was related to moose and woodland caribou requirements (Keith Wade personal communication). A second project based out of Marathon, radio-collared wolves from Neys Provincial Park to White Lake. This research examined habitat use and home ranges related to roads and landscape parameters and also the influence of garbage dumps (Krizan and Krizan 1997).

6.1.10.6 Canada Lynx

Canada lynx was formerly found throughout the Lake Superior basin, but its range has receded northward and it is now largely restricted to Ontario within the basin. The U.S. Fish and Wildlife Service proposed to list the Canada lynx as threatened under the Endangered Species Act in 1998.

Habitat is associated with cool coniferous forest in southern extensions of boreal forest into the U.S. (McKelvey and others 1999). Young, dense forest stands, where snowshoe hares are abundant, are critical, but lynx home range typically also includes mature forest with large woody debris for denning (Aubrey and others 1999).

Lynx populations fluctuate widely in response to snowshoe hare numbers. Following declines in prey, lynx wander from their core Canadian range into Minnesota, Michigan and Wisconsin. Particularly large incursions from Ontario into the states happened in the early 1960s and again in the early 1970s (McKelvey and others 1999).

The recession of lynx range in the U.S. is related to changes in forest conditions, loss of coniferous forest cover, trapping and roads. Timber management practices and fire suppression that lead to poor snowshoe hare habitat is detrimental to lynx. Increased roads threaten lynx due to increased access for trappers, and competitors such as coyotes and bobcats (Koehler and Aubrey 1994).

Michigan

Lynx were formerly widely distributed in the Upper Peninsula and Isle Royale, but virtually extirpated by 1938 (McKelvey and others 1999). The last record in the state was a trapping record from the early 1980s in Mackinac County. Lynx are now listed as endangered in Michigan.

There is good habitat, large continuous mixture of boreal and hardwood forest in the Upper Peninsula. (Kevin Dorn, personal communication), but habitat availability has not been quantified (Ray Rustem, personal communication). The Department of Natural Resources monitors trapping records, but does not conduct annual surveys.

The National Forest Service initiated a three-year monitoring program for cat species in 1999. The survey covers the West Block of the Hiawatha National Forest and will be expanded into the East Block of the Hiawatha Forest and the Ottawa National Forest in the winter of 1999/2000. Monitoring involves placing scratch pads, marked with catnip oil and then collecting hair samples for DNA sampling (Kevin Dorn personal communication).

Wisconsin

Lynx were listed as Endangered in Wisconsin in 1973, but removed from the list in 1997 due to lack of evidence of a breeding population (Wydeven and others 1999). Two lynx were killed in 1992; the first specimens collected since 1974 (Adrian Wydeven personal communication). Between 1991-1997 there were 10 reports of lynx with three observations in both 1992 and 1993. The Wisconsin DNR monitors lynx by conducting furbearer snow track surveys, wolf track surveys, reports of rare carnivores by public and survey of bobcat hunters and trappers. Lynx are considered to be very rare and probably not breeding in the state.

There has been no quantitative habitat survey, but habitat may be marginal with limited areas of boreal forest. Competition for prey with coyotes and bobcats may limit lynx distribution (Adrian Wydeven personal communication).

Minnesota

The status of lynx in Minnesota in the late 1800s and early 1900s is unclear due to possible confusion of early records with bobcats (McKelvey and others 1999). Lynx are a protected furbearer in Minnesota and the trapping season has been closed since 1984. Predator scent station and snow track surveys are conducted annually.

Lynx numbers in Minnesota reflect irruptions from Ontario and many records are assumed to be transient animals from Ontario, rather than a resident population. There were peaks in fur harvest returns in 1930, 1940, 1952, 1962 and 1973 (McKelvey and others 1999). In 1973, four hundred lynx were harvested in the state; in 1982, 42 lynx were harvested; and in the 1990s there has only been one record in Minnesota. These irruptions followed the snowshoe hare peak in each decade (Mike DonCarlos personal communication).

Potential habitat for a resident, breeding population within the Lake Superior basin is restricted to portions of Cook, Lake, and St. Louis counties (published and unpublished data collected by L. David Mech; cited in DonCarlos 1994). Habitat consists of areas with snowshoe hare and no bobcats.

Ontario

Lynx are distributed throughout the Ontario portion of the Lake Superior basin. Populations fluctuate with snowshoe hare numbers, but range has apparently been stable (Dobbyn 1994). Lynx have no official protection status, except their classification as fur-bearer.

Trapping records are the only quantitative population data available in Ontario (Neil Dawson, personal communication). In 1999, a survey was sent out to trappers in Ontario asking them to assess the current population of lynx and to give an opinion of population change in their area. In the five districts that border Lake Superior, 38 trappers responded to the questionnaire. Ten indicated that lynx were not present, 18 said lynx were scarce, seven stated lynx were common and three reported lynx abundant. Regarding population change, four indicated a decrease in population, three an increase and fifteen reported numbers about the same.

Lynx habitat supply hasn't been quantified, but is probably not limiting, (Neil Dawson, personal communication).

6.1.10.7 Northern Brook Lamprey

Northern brook lamprey (*Ichthyomyzon fossor*) is a non-parasitic species. Its range includes parts of the Mississippi, Hudson Bay, and Great Lakes drainages. In the Lake Superior basin, it is known from a number of small streams in Ontario, Michigan and Wisconsin (Scott and Crossman 1973).

This species apparently does not move out to Lake Superior, but completes its life cycle in streams. Larval lampreys live in streambeds and feed on diatoms and protozoans. When the larvae hatch they make burrows in soft mud and spend six years growing. Following metamorphosis into an immature adult stage, they overwinter in the mud and emerge to spawn. Adults never feed and live for about a year before dying.

Northern brook lamprey is classified as vulnerable at the federal level in Canada (Lanteigne 1991). It is primarily a warm water species and may never have been common here. Larvae are subject to mortality by lowering water levels and increased siltation from erosion. Habitat may be limited by lampricide intended to control sea lampreys (Scott and Crossman 1973). Seventy-nine (45 United States, 34 Canada) Lake Superior tributaries have been treated with lampricide at least once during 1987 - 96. Of these, 53 (30 United States, 23 Canada) tributaries are treated on a regular (3-5 year) cycle (Klar and others 1996). Northern brook lamprey persists in untreated streams, and above barriers and in backwater areas which are not affected by the treatments (Lanteigne 1991, Royal Ontario Museum 1999).

6.1.10.8 Lake Sturgeon

A commercial sturgeon fishery had started by the early 1800's and the lake sturgeon population probably began to decline in the mid 1800's. By the late 1800's, the stock had declined dramatically. Low reproductive rate and slow growth made sturgeon vulnerable to over-fishing. Despite harvest restrictions implemented in the 1920's, sturgeon were commercially extinct in Lake Superior by 1940 (Waters 1987). Sturgeon populations have not recovered to historical levels (Hansen 1994).

Lake sturgeon prefer nearshore waters, 4 to 9 m deep, but are occasionally found at depths up to 43 m (Harkness and Dymond 1961). Shoals and embayments where benthic organisms are most abundant are the preferred foraging areas. Offshore waters (> 80 m) are not used. Spawning occurs in rapids in streams or in lakes over shallow rocky ledges and shoals where wave action keeps the eggs oxygenated (Scott and Crossman 1973). Larval fish drift downstream after hatching and typically remain in the stream or shallow waters for the first two years. Juvenile habitat requirements are poorly understood. Yearlings are sometimes found over flat sandy areas.

Nine Lake Superior tributaries currently have self-sustaining sturgeon populations (Table 6-25, Figure 6-51) (Auer 1999). Populations in all nine are reduced from historical levels. Another nine tributaries were historically used for spawning, but are not presently used.

The decline of sturgeon on Lake Superior was largely due to over-fishing, but habitat loss also contributed. Dams on spawning rivers created barriers for spawning migration and altered natural stream flow regimes during the spawning period. Unnaturally low water levels can kill embryos by exposing them to air. High flows can dislodge eggs or embryos from the substrate (Kempinger 1988). Adults are sometimes trapped by falling water levels (Sehler and others 1996). Deposition of bark and other debris from log drives buried spawning beds (Harkness and

Dymond 1961) and changes in land use along streams may have increased sedimentation and degraded water quality.

Dredging shipping channels in nearshore waters and harbor construction and shipping at river mouths contributed to decline in benthic organisms. Barriers constructed for sea lamprey treatments block migration of spawning adult sturgeon. Young sturgeon may be vulnerable to lampricide (Auer 1999).

A rehabilitation plan for lake sturgeon in Lake Superior (Auer 1999) recommends several habitat-related measures, including (i) protecting existing habitat (ii) restoring natural stream flow regimes through re-licensing criteria for hydroelectric dams (iii) providing passage past barriers and dams and (iv) minimizing the impact of sea lamprey control activities. Eight "critical management areas", with suitable habitat and existing spawning stocks, are priorities for rehabilitation and protection (Figure 6-52). Other recommendations involve harvest, stocking and contaminants.

Information needs include (i) basic life history and abundance data (ii) descriptions and of nursery, juvenile and adults habitats (iii) quanitification and mapping of habitat.

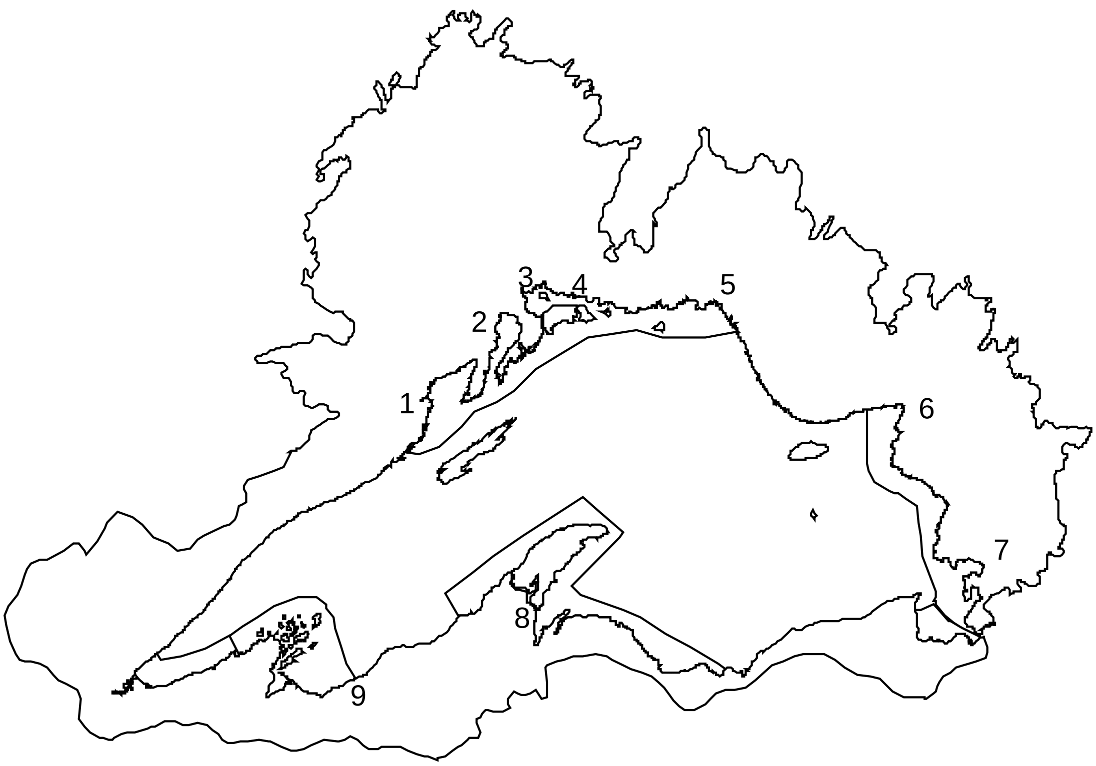


Figure 6-52. Critical management areas for lake sturgeon.
Numbers indicate self-sustaining spawning tributaries (Table 6-24) (Auer 1999).

Table 6-24 Tributaries with current or historical lake sturgeon populations (Auer 1999). Numbers refer to stream locations on Figure 6-52

Tributary	Status	Stressors
Pigeon River, MN/ON	Historical	
St. Louis River, MN/WI	Historical	Exotic species, loss of wetlands
Bad River, WI (8)	Current	Sedimentation, harvest
*Ontonagon River, MI	Historical	Erosion, loss of wetlands, regulated flow, dredging in lower river
Sturgeon River, MI (9)	Current	Dam, sediment loads, regulated water levels
Tahquamenon River, MI	Historical	Sedimentation, past logging practices, little spawning habitat
Batchewana River, ON	Historical	
Big Pic River, ON (5)	Current	
*Black Sturgeon River, ON (2)	Current	Dam, historical logging
Goulais River, ON (7)	Current	
Gravel River, ON (4)	Current	
Harmony River, ON	Historical	
Kaministiquia River, ON (1)	Current	
*Michipicoten River, ON (6)	Current	Dam, poaching, regulated water levels
Montreal River, ON	Historical	Regulated flow
Nipigon River, ON (3)	Current	Dam, regulated water levels
White River, ON	Historical	
*Wolf River, ON	Historical	Dam, lamprey barrier

* priorities for habitat restoration

Table 6-25 Embayments important to lake sturgeon in Lake Superior (Auer 1999)

Harbor/ Bay	Most Recent Observation	Stressors
Grand Portage Bay, MN	1995	
St. Louis, MN/WI	1997	
Chequamegon, MI	1997	
Bete Gris, MI	1993	Fishing
Huron, MI	1995	Siltation from poor stream crossings, logging practices, fishing
Keweenaw Bay, MI	1996	Treated waste management, treated paper mill effluent , fishing
Misery, MI	1995	Fishing
Munising Bay, MI	1991	Fishing
Whitefish Bay, MI	1997	Dredging for ship channel, contaminants, fishing
Batchewana Bay, ON	1997	Habitat loss
Black Bay, ON	1996	
Clark's Bay, ON	1997	
Goulais Bay, ON	1997	Bycatch of juveniles
Michipicoten , ON	1997	
Nipigon Bay, ON	1997	
Thunder Bay, ON	1997	Shoreline development
Wawanagon Bay, ON	1997	

6.1.10.9 Arctic Grayling

Arctic grayling (*Thymallus arcticus*) formerly inhabited the Otter River and Little Carp River in the Lake Superior watershed of the Michigan Upper Peninsula, as well as several streams in the Lower Peninsula (Hubbs and Lagler 1958). Relict populations of this arctic species were found in Montana and Michigan. Michigan populations disappeared by about 1936.

The extirpation of grayling from Michigan was caused by overfishing and habitat modification caused by logging (Eddy and Underhill 1974). Grayling spawn in the shallow water of small streams on sand and gravel substrate. This habitat is vulnerable to sedimentation, warming water and pollution.

Suitable habitat to support this species may no longer be present in the basin. The state of Michigan stocked grayling into several lakes and streams between 1987 and 1991 (Nuhfer 1992). Most stream populations disappeared within six months as fish dispersed downstream. Dams and warm water impoundments hampered survival and dispersal upstream. Some lake populations persisted where competition and predation by other fish species was low. Hooking mortality, illegal harvest, diseases and episodes of low pH were significant mortality factors (Nuhfer 1992). No reproduction has been detected. Introduction attempts in Minnesota (Musquash Lake and Twin Lake) and Ontario (Blue Lake) in the 1950s had similar results (Eddy and Underhill 1974, Scott and Crossman 1973).

6.1.10.10 Deepwater Ciscoes

Deepwater ciscoes consist of seven species, five of which inhabited Lake Superior: blackfin cisco (*Coregonus nigripinnis)*, shortjaw cisco (*C. zenithicus)*, bloater *(C. hoyi)*, shortnose cisco *(C reighardi)*, and kiyi (*C. kiyi)*. Two other species, deepwater cisco *(C. johannae)* and longjaw cisco *(C. alpenae)* were found only in the lower Great Lakes, but longjaw cisco is now probably extinct. Blackfin cisco is now probably extirpated from Lake Superior, although it is still found in Lake Nipigon and other inland lakes. All but blackfin cisco and shortjaw cisco were endemic to the Great Lakes (Scott and Crossman 1973). Three of these are listed federally in Canada: shortnose cisco (Threatened), shortjaw cisco (Threatened), and kiyi (Vulnerable).

Ciscoes formerly supported a substantial fishery in the Great Lakes. Fish were caught in deep-water gill nets, smoked and sold in the U.S. Fishermen targeted the larger, fatter species (blackfin, deepwater, and longjaw), until these stocks collapsed and then moved on to smaller species. The commercial cisco fishery declined through the 1940s and 1950s and collapsed by about 1960. Cisco populations increased though the early 1960s, apparently in response to decline of lake trout, an important predator (MacCallum and Selgeby 1987). Deepwater cisco populations declined again between the mid-1960s through the mid-1990s, possibly as a result of expanding lake trout population (Selegeby and others 1994, MacCallum and Selgeby 1987). Throughout this period, social factors, such as operating costs, demand and prices, caused some variability in catch. The bloater is the only species left in large numbers today (Hansen 1994).

Competition for food with introduced smelt and alewife may also have been a factor in their decline. Sea lamprey preyed on the larger cisco species (Lawrie and Rahrer 1972), but lamprey-caused mortality was offset by declines in their major predator, lake trout. Hybridization between closely related species may have hastened the decline of rarer species (Scott and Crossman 1973). Oxygen depletion resulting from eutrophication contributed to the decline in the lower Great Lakes, but was probably not a factor in Lake Superior (McAllister and others 1985, ROM 1998, Scott and Crossman 1973).

The present status of deepwater ciscoes is clouded by uncertain taxonomic status of the species and difficulty in monitoring. Hybridisation between species and with the ubiquitous lake herring apparently took place as stocks began to decline, resulting in populations with characteristics intermediate between their parent species. Their deepwater habitat also makes it difficult to determine population levels (Parker 1989).

Chemical and physical habitat changes do not appear to have had an adverse impact on these species. Deepwater ciscoes are protected indirectly in the Great Lakes through Canadian and U.S.

commercial harvest quotas for all deepwater ciscoes as a group. In Canada, they have the general protection given by the habitat sections of the Fisheries Act (ROM 1998). No recovery plans have been developed by U.S. or Canadian governments.

Kiyi

The Kiyi is still relatively common in Lake Superior, but is extirpated from the other Great Lakes (McAllister and others 1985). It is one of the smaller deepwater ciscoes, but otherwise very similar to the shortjaw cisco and the bloater (a common deepwater cisco). It occurs at depths of 35 - 200 m but usually at more than 100 m (ROM 1998). Changes in chemical habitat features, likely responsible for the extirpation of this species in the other Great Lakes, have apparently not resulted in significant habitat degradation for Kiyi in Lake Superior.

Shortjaw Cisco

Shortjaw cisco lives in deep waters (50-150 metres depth) where it can grow to a length of up to 35 centimetres. It is found in Lake Superior, Lake Nipigon and in scattered inland lakes from northern Ontario west to the Northwest Territories. It is extirpated from lakes Michigan and Huron (Houston 1988, ROM 1998). The USGS Ashland Biological Station is attempting to relocate the shortjaw cisco at known historical sites (Bob Kavetsky, personal communication).

Shortnose Cisco

Shortnose cisco is one of the smaller deepwater ciscoes and it inhabits shallower water than the other species (depths of 25-100 meters). It is the only deepwater cisco that spawns in the spring rather than fall and winter, although recently spawning has occurred in the fall in Lake Michigan (McAllister and others 1985, Parker 1988c, Webb and Todd 1995).

The historical status of shortnose cisco in Lake Superior is uncertain. Populations formerly reported from lakes Nipigon and Superior are now considered by some authorities to be shortjaw cisco. Shortnose cisco was known only from Lakes Huron, Michigan and Ontario, but may now be extinct (Bob Kavetsky, personal communication, McAllister and others 1985, ROM 1998, Scott and Crossman 1973). As with the other deepwater ciscoes, overharvest and sea lamprey predation, rather than habitat degradation, are probably responsible for its decline.

6.1.10.11 Pitcher’s Thistle

Pitcher’s Thistle (*Cirsium pitcheri*) is a Great Lakes endemic plant. Most of its range is on Lake Huron and Lake Michigan shores in Ontario, Michigan and Wisconsin. Habitat is open sandy beaches and dunes (White and others 1983).

On Lake Superior, Pitcher’s thistle is known from two locations: Oiseau Bay in Pukaskwa National Park (White and others 1983) and Grand Sable Dunes in Michigan (Voss 1996). A thorough search of other suitable habitat on the Michigan shore failed to find any additional populations (Voss 1996).

Threats to Pitcher's thistle habitat include shoreline development, succession, shoreline modifications that change sand accumulation and overgrazing from deer. A long term monitoring program in Pukaskwa National Park, Ontario, found that the population dropped from a maximum of over 700 plants to less than 200 plants following the failure of an upstream beaver dam, causing a creek to re-route its channel. The population remained low for five years, but then rebounded in 1996 (Promaine 1999). Periodic disturbances of this sort may in fact improve habitat conditions for the species by reducing competition from other species. This population is relatively secure from human trampling and overgrazing from deer.

A recovery plan for Michigan populations is scheduled for release in 2000.

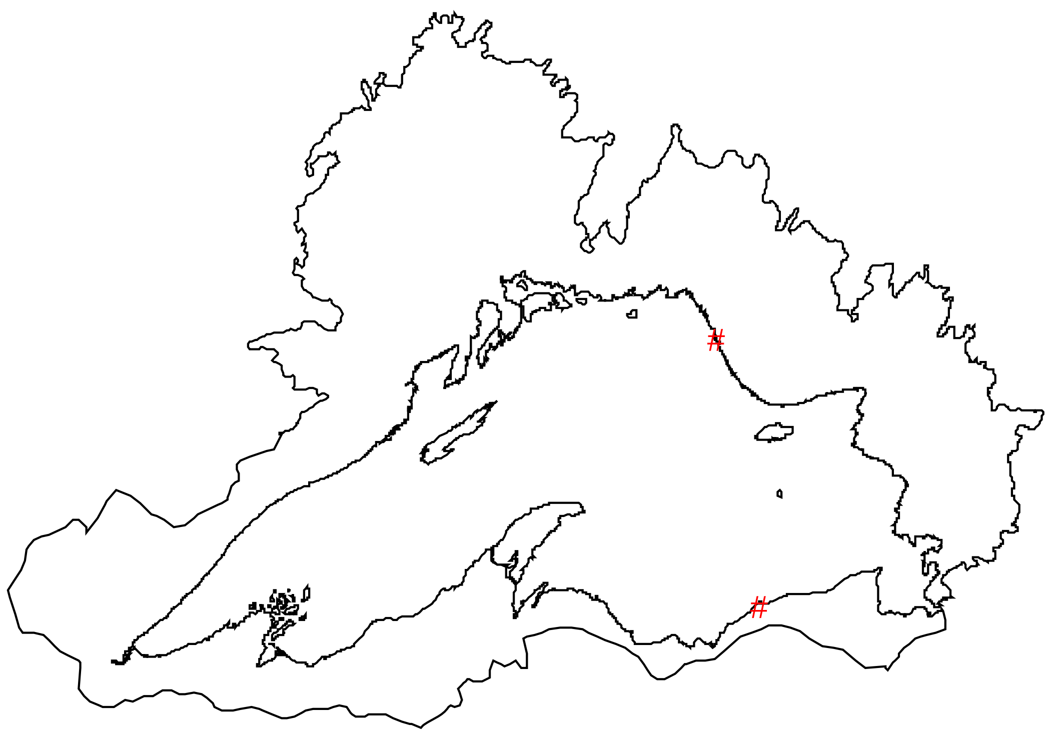


Figure 6-53. Pitcher's Thistle Population

6.1.10.12 Lake Huron Tansy

Lake Huron tansy *(Tanacetum huronense)* range extends from Maine and the Maritime Provinces, to Hudson Bay and northern Alberta. In the Great Lakes Region, it is found in northern Michigan, the Door Peninsula in Wisconsin and eastern Lake Superior shore in Ontario (Soper and others 1989, Voss 1996).

Its preferred habitat is active sand dunes and upper sand or cobble beaches within the wave zone during high water. It occasionally grows in limestone crevices. Depauperate plants sometimes persist on older stabilized dunes (Voss 1996).

Lake Huron tansy is known from the Michigan portion of the Lake Superior basin from Alger, Luce and Chippewa counties in the Upper Peninsula (Voss 1996). In Ontario, it is found at the Sand River mouth on the eastern side of the lake (Bakowsky 1998). Ontario authorities (Argus and others 1982 - 1987) consider Lake Huron Tansy to be a subspecies of *T. bipinnatum*, which is common and widespread on the James Bay – Hudson Bay coast and therefore not tracked.

6.1.10.13 Houghton's Goldenrod

Houghton's goldenrod *(Solidago houghtonii*) is another Great Lakes shoreline endemic. It typically grows in interdunal shoreline wetlands and low dunes and moist sandy beaches (Voss 1996). Fluctuating water levels of the Great Lakes play a role in maintaining its habitat. During high water, plant are submerged, but some plants survive the inundation and new seedlings establish on the moist sand (USFWS 1999).

Its primarily range is the northern shores of Lakes Michigan and Huron. In Michigan, it is found in the Lake Superior basin in Chippewa County (Voss 1996). Houghton's goldenrod is rare in Ontario, but is not known from the Ontario part of the basin (Oldham 1999, Semple and Ringius 1983).

Threats to Houghton’s goldenrod include trampling from foot and vehicular traffic associated with increased human activity on shorelines (USFWS 1999). Conservation efforts in Michigan include landowner contacts, monitoring, habitat protection in parks and reserves (USFWS 1999).

6.1.10.14 Ginseng

Ginseng (*Panax quinquefolius*) is at the northern edge of its range in the Lake Superior basin. Although relatively widespread in the southern parts of Ontario, Minnesota, Wisconsin and Michigan, its range within the basin is confined to Gogebic County in Michigan and adjacent Vilas County in Wisconsin (Argus and White 1984, Coffin and Pfannmuller 1988, Michigan Natural Features Inventory 1996). Ginseng is Threatened in Michigan, Special Concern in Wisconsin and Minnesota and rare (S3) in Ontario. At the federal level, ginseng is Threatened in Canada and Special Concern in the US.

Ginseng has declined throughout its range due to overharvest as an herbal medicine. This has resulted in loss of local populations and contraction of range.

Preferred habitat is rich hardwood forest with loamy soil, especially on slopes and ravines (Coffin and Pfannmuller 1988, Michigan Natural Features Inventory 1996).

Habitat related concerns include forest fragmentation (which inhibits natural reestablishment after harvesting), logging, heavy grazing by deer, and cattle grazing in woodlots (Michigan Natural Features Inventory 1996, Coffin and Pfannmuller 1988).

Ginseng export is regulated by the Committee on International Trade in Endangered Species (CITES). It is also protected by legislation in Michigan and Ontario.

6.1.10.15 Other Rare Plants and Animals

Numerous other plants and animals in the Lake Superior basin are rare at the state or provincial level. These include species with fewer than 100 occurrences in the state/province (i.e. “S1”, “S2” or “S3” following The Nature Conservancy rankings). Species that are rare in at least one state or province are listed in Addendum 6-A. It is important to note that some species listed here as rare are on the list because of habitat loss or population declines elsewhere in one or more of the states or the province. In some cases, such as with the kiyi, habitat in the Lake Superior area and populations of the species here are neither declining nor particularly degraded at the scale of the watershed. In these cases, habitat protection in the Lake Superior watershed is critically important.

Birds

Over 50 bird species are considered rare in at least one state/province. This includes species that are rare in the southern portion of the basin, but abundant in Ontario (Yellow-bellied Flycatcher, Tennessee Warbler, Swainson’s Thrush).

American White Pelican, although listed as endangered in Ontario, is increasing in numbers and expanding its range eastward. Pelicans now nest on Lake Nipigon in the Lake Superior basin, and may further expand their range since non-breeding birds are frequently seen on Lake Superior throughout the summer (Escott 1991, Bryan 1994).

Forest fragmentation and loss of mature forest cover threaten forest-dwelling birds such as cerulean warbler and red-shouldered hawk (WI DNR 1999). Protection of extensive mature forested tracts, especially mature floodplain habitats in Wisconsin and Minnesota will benefit these species.

Other threats to bird species include loss of wetlands (yellow rail, black tern), chemical contamination (merlin, osprey) and destruction of shoreline habitat (common tern).

Fish

Ten rare fish species are known from the Lake Superior basin (Addendum 6-A). Of these, northern brook lamprey, lake sturgeon, and deepwater ciscoes have been discussed in detail elsewhere in this report.

Silver lamprey (*Ichthyomyzon unicuspis)* and American brook lamprey (*Lampetra appendix)* live in similar habitats and are subject to similar stresses as northern brook lamprey.

Deepwater sculpin (*Myoxocephalus thompsoni*) inhabits deep lakes from Quebec to the Northwest Territories. Populations in Lake Superior and Lake Huron appear healthy, but the species is extirpated in Lake Erie and was only recently rediscovered in Lake Ontario. The Great Lakes populations are therefore classified as threatened in Canada (Parker 1988a). The decline of deepwater sculpin in the lower Great Lakes may be related to exposure to contaminants in lake sediments. Predation on larva by introduced fishes may have also played a role (Parker 1988a).

Paddlefish (*Polyodon spathula*) is known from a single record in the Lake Superior basin; a specimen from the Nipigon River in Ontario (McAllister and others 1985). Paddlefish is now extirpated in Ontario.

Three species of herring from the Lake Superior basin: Lake Ives cisco (*Coregonus hubbsi*), known from Lake Ives in the Huron Mountains of Michigan; Siskiwit Lake cisco (*C. bartletti*) from Siskiwit Lake on Isle Royale; and Nipigon Tullibee (*C. nipigon*) from Lake Nipigon and Black Sturgeon Lake have been described as full species (Hubbs and Lagler 1958), but are now generally regarded as members of the lake herring (*C. artedii*) “complex” (Scott and Crossman 1973).

Invertebrates

Rare invertebrates of the basin include 34 insect species and three mollusks. The distribution and abundance for some of these species is poorly understood and may be more common than their rankings suggest. Conversely, other rare species may be present, but not yet documented.

Several rare insects are associated with sand dunes and beaches. Beach dune tiger beetle *(Cicindela hirticollis)* inhabits sand beaches in the Ontario and Wisconsin parts of the basin. It is extirpated from some historical Ontario sites, possibly due to loss of habitat to shoreline development (Marshall 1999). Lake Huron locust (*Trimerotropis huroniana*) is endemic to the Great Lakes region. It occurs on sand dunes along the Lake Superior coast in from Chippewa to Alger counties in Michigan and in northeastern Wisconsin (Rabe 1999). Preferred habitat is extensive, sparsely-vegetated dunes with unstable sand and blowouts (Rabe 1999). Habitat loss from shoreline development and habitat degradation due to invasive weeds or disruption of sand movement cause populations to decline (Rabe 1999). Dune cutworm (*Euxoa aurulenta*) is a moth known from Whitefish Point in Michigan. It inhabits similar habitats and is threatened by similar factors as the Lake Huron locust (Cuthrell 1999a).

Reptiles and Amphibians

Two rare species of reptiles are known form the Lake Superior basin. Wood turtle (*Clemmys insculpta*) and Blanding's turtle (*Emydoidea blandingii*) are threatened in Wisconsin and Minnesota. Wood turtle is Special Concern in Michigan. They are at northwestern limit of their range in the Lake Superior basin.

Wood turtles inhabit small, clear fast streams with sandbars and meadows. In Michigan, they are distributed throughout much of the Upper Peninsula, but are restricted to small pockets of suitable habitat (Lee 1999). A significant threat to wood turtles is the disturbance of nesting areas by recreational use of sandbars and sandy banks by off-road vehicles, canoeists and anglers. Other threats include stream degradation, loss of forest cover along streams and overcollecting for the pet trade (Coffin and Pfannmuller 1988).

Blandings turtles live in rich wetlands near sandy uplands for nesting. Loss of wetland habitat, river channelization and dams are among the factors threatening populations (Coffin and Pfannmuller 1988).

Mammals

Three rare bat species: eastern small-footed bat (*Myotis leibii*), northern myotis (*Myotis septentrionalis*) and eastern pipistrelle (*Pipistrellus subflavus*) are known from the basin, but are at the northern and western limits of their ranges. Suitable caves for hibernating may be a limiting factor (Coffin and Pfannmuller 1988).

Pine marten (*Martes americana*) populations in the US portion of the basin declined in the late 1800s, and were thought to be extirpated from Minnesota and Wisconsin by the 1920s. Marten became re-established in northern Minnesota by the 1950s and are relatively common there now. Re-introduced populations have been established in northern Wisconsin (Wisconsin Dept. of Natural Resources 1999). Loss of mature, coniferous forest habitat related to logging and human settlement, as well as over-trapping, probably contributed to their decline (Coffin and Pfannmuller 1988). In Ontario, marten are relatively common and widespread. Recently introduced marten habitat guidelines call for maintaining large contiguous blocks of "core habitat" consisting of mature coniferous forest.

Cougar (*Felis concolor*) and wolverine (*Gulo gulo*) may have once inhabited the Lake Superior basin, but are apparently extirpated now. Occasional sighting of both species are reported, but these probably represent wandering individuals rather than a resident population. Some cougar sightings may be escaped pets. Cougar and wolverine require large tracts of habitat with low human disturbance. Persecution by humans and large scale changes in forest habitat probably contributed to their decline.

Plants

About 300 species of rare plants are found in the Lake Superior basin. This represents approximately 10 percent of the total number of plant species growing in the basin (Thunder Bay Field Naturalists 1998, Coffin and Pfannmuller 1988).

Many of these species are at the periphery of their range and have always been rare here. Some species are rare in one of the states/province, but common in others.

A breakdown of Minnesota’s rare plants by habitat consists of 40 percent wetland species, 17 percent cliff/bedrock species, 15 percent prairie species, and 13 percent upland forest species. The rest are found in successional or transitional habitats. Most (78 percent) rare plant populations in Minnesota occur outside of protected areas (Coffin and Pfannmuller 1988).

Threats to rare plant populations include, logging, plowing native prairies, and water quality changes.

Some areas have higher concentration of rare plant habitats because of unusual features of climate, geology, and glacial history (Coffin and Pfannmuller 1988). Areas with concentrations of rare plant habitats are shown in Figure 6-54 and described in Table 6-26.

The moonworts (*Botrychium spp.*), consisting of several species of small ferns, deserve special mention. The majority of the global range of three of these species falls within the Lake Superior basin. They are false northwestern moonwort (*B. pseudopinnatum*), pale moonwort (*B. pallidum*), and pointed moonwort (*B. acuminatum*) (Wagner and Wagner 1993). Habitat for these species is primarily open sandy areas, dunes, and old fields.

Table 6-26 Rare plant habitats
Refer to Figure 6-54 for locations (Argus and others, Coffin and Pfannmuller 1988, Epstein and others 1997, Soule 1993)

	Area	Description	Example species
1	Northshore Islands and shorelines	Arctic-alpine disjunct species	*Oplopanax horridus, Carex atratiformis*
2	Sibley Peninsula	Cliff communities, calcium-rich bedrock	*Malaxis paludosa, Arnica cordifolia*
3	Stanley Prairie	Relict prairie community	*Erigeron glabellus, Stipa comata*
4	Nor'Wester Mountains and Minnesota Border Lakes	Open cliff base and rim communities	*Calamagrostis purpurescens, Senecio eremophilus*
5	Minnesota Northshore	Arctic-alpine disjunct species	*Sagina nodosa, Draba norvegica*
6	St. Louis River Estuary	Wetland communities	*Sparganium glomeratum, Petasites sagittatus*
7	Bayfield Peninsula	Boreal species, wetlands	*Armoracia lacustris, Huperzia selago*
8	Apostle Islands	Boreal and sub-arctic species	*Senecio indecorus, Pinguicula vulgaris*
9	Isle Royale	Arctic-alpine disjunct species	*Calamagrostis lacustris, Phacelia franklinii*
10	Keweenaw Peninsula	Coastal communities, arctic-alpine species	*Arnica cordifolia, Chamaerhodos nuttallii var. keweenawensis*
11	Eastern Michigan shoreline	Sand dune species	*Cirsium pitcheri, Tanacetum huronense*

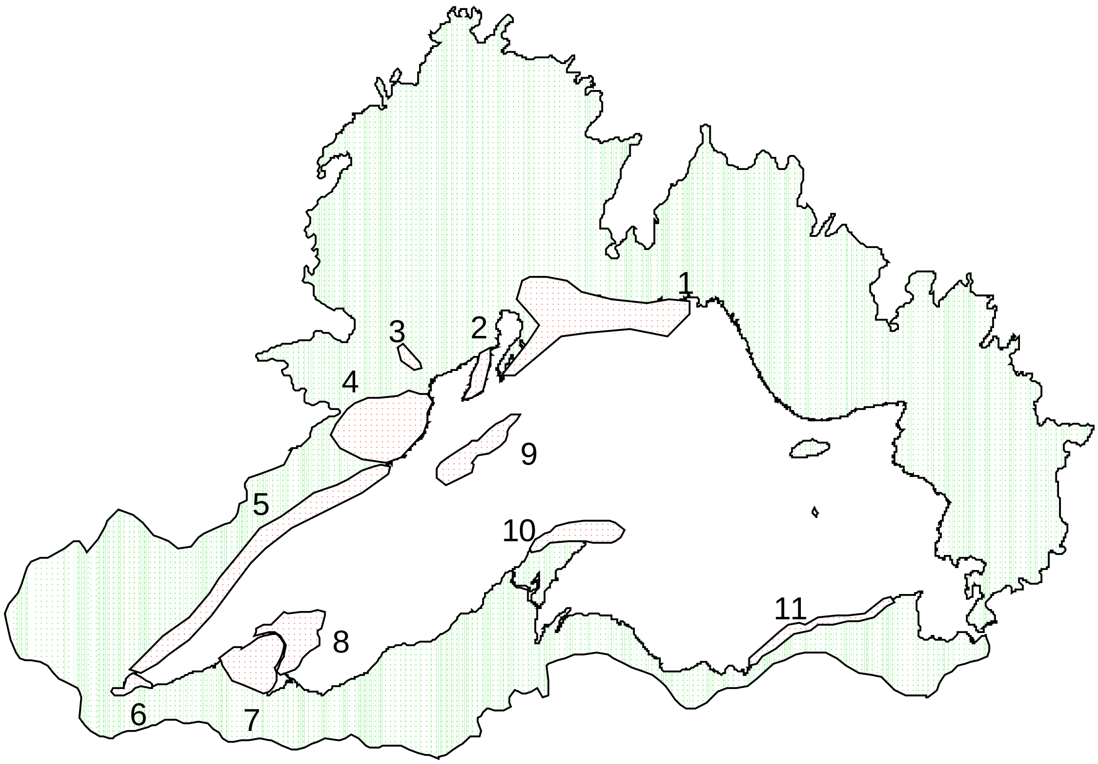


Figure 6-54. Rare plant habitats
Refer to Table 6-26 for descriptions

6.1.10.16 Rare Communities

The Lake Superior basin is home to several globally rare vegetation communities. Many are directly dependent on lake processes for their existence and support many of the rare species that inhabit the basin (Reid and Holland 1997).

This section describes some of the more prominent rare community types. A list of globally rare communities known from the Lake Superior basin is in Addendum 6-B. This list continues to be revised and updated as inventory work by the state and provincial agencies progresses.

Sand Dunes

Several communities associated with Great Lakes sand dunes are considered to be globally rare by the Nature Conservancy (Addendum 6-B). They form as sand is eroded from glacial sediments by waves and streams and moved along the coast and deposited. Dunes actively move as wind continues to move the sand.

Coastal dunes have a characteristic series of zones. Foredunes develop closest to the beach, where vegetation such as marram grass (Ammophila breviligulata) and American dune grass (*Leymus molis*) forces the winds to drop sand. Other plants such as beach pea (Lathyrus japonicus) and wormwood (Artemisia campestris) are established as the foredune grows. Trees and shrubs such as white spruce (Picea glauca), trembling aspen (Populus tremuloides), sand cherry (Prunus pumila), dogwood (Cornus stolonifera), and willows (Salix spp.) eventually gain a foothold (Reid and Holland 1997).

Interdunal areas lie protected from wind and waves behind the foredunes. These areas include globally imperiled communities called interdunal wetlands (pannes) which are calcareous, depressions kept moist by the water table. Vegetation in interdunal wetlands includes shrubby cinquefoil (*Potentilla fruticosa*), twig-rush (*Cladium mariscoides*) and baltic rush (*Juncus balticus*) (Michigan Natural Features Inventory 1999a).

Wooded dune and swale community complexes develop as post glacial uplift causes the lake level to recede, leaving dunes outside the direct influence of the lake and allowing new foredunes to form. Over several thousand years, this eventually results in a series of ridges and swales. Streams and groundwater keep the swales moist. Forest eventually develops on the older dunes. Jack pine, red pine and white pine are the dominant tree species, with white cedar and wet meadow in the swales (Michigan Natural Features Inventory 1999b).

The largest and most extensive dunes on Lake Superior are at Grand Sable Dunes National Lakeshore. Some dunes here are several hundred feet high (Reid and Holland 1997). Ontario's dunes are small, scattered cove dunes that develop in rocky coves of irregular coastines. The largest examples are in Ney's Provincial Park (0.9 km^2), at the mouths of the Pic and Sand rivers (0.4 km^2 each) (Bakowsky 1987).

Rare species found in dune habitats include Lake Huron Tansy, Houghton's goldenrod, Pitcher's thistle, Lake Huron locust, piping plover and dune cutworm.

Dunes are threatened by are residential development and roads which displace native species and disrupt natural sand migration. Off-road vehicles and other recreational use increase erosion. Sand mining, logging of forested dunes, and exotic plants are other threats (Michigan Natural Features Inventory, 1999a, 1999b).

Sand Beaches

Great Lakes sand beaches are considered to be globally rare by the Nature Conservancy (Addendum 6-B).

Sand beaches typically consist of a series of zones. The *lower beach* is scoured by waves and devoid of vegetation. The sparsely vegetated *middle beach* collects debris deposited by storms. The *upper beach* is vegetated with biennials and perennials such as wormwood and beach pea (Reid and Holland 1997). On Lake Superior, sand beaches are often associated with sand dunes, river mouths, and sheltered bays.

Lake Superior has a total of 665 km of sand beach (Canada 256 km; US 409 km), predominantly on the southern shore (Figure 6-55). The longest sand beach is a sand spit at the mouth of Chequomegon Bay in Wisconsin at 21 km in length. There are 161 sand beaches greater than 1 km long (Canada 60; US 101), but most are short, narrow stretches .

A number of rare flora and fauna are associated with sand beaches, many of which are shared by sand dune communities. These include Pitcher's thistle, Lake Huron Tansy, and piping plover. Many smaller beaches may be too small and isolated to support many of the plants and animals characteristic of the larger beaches.

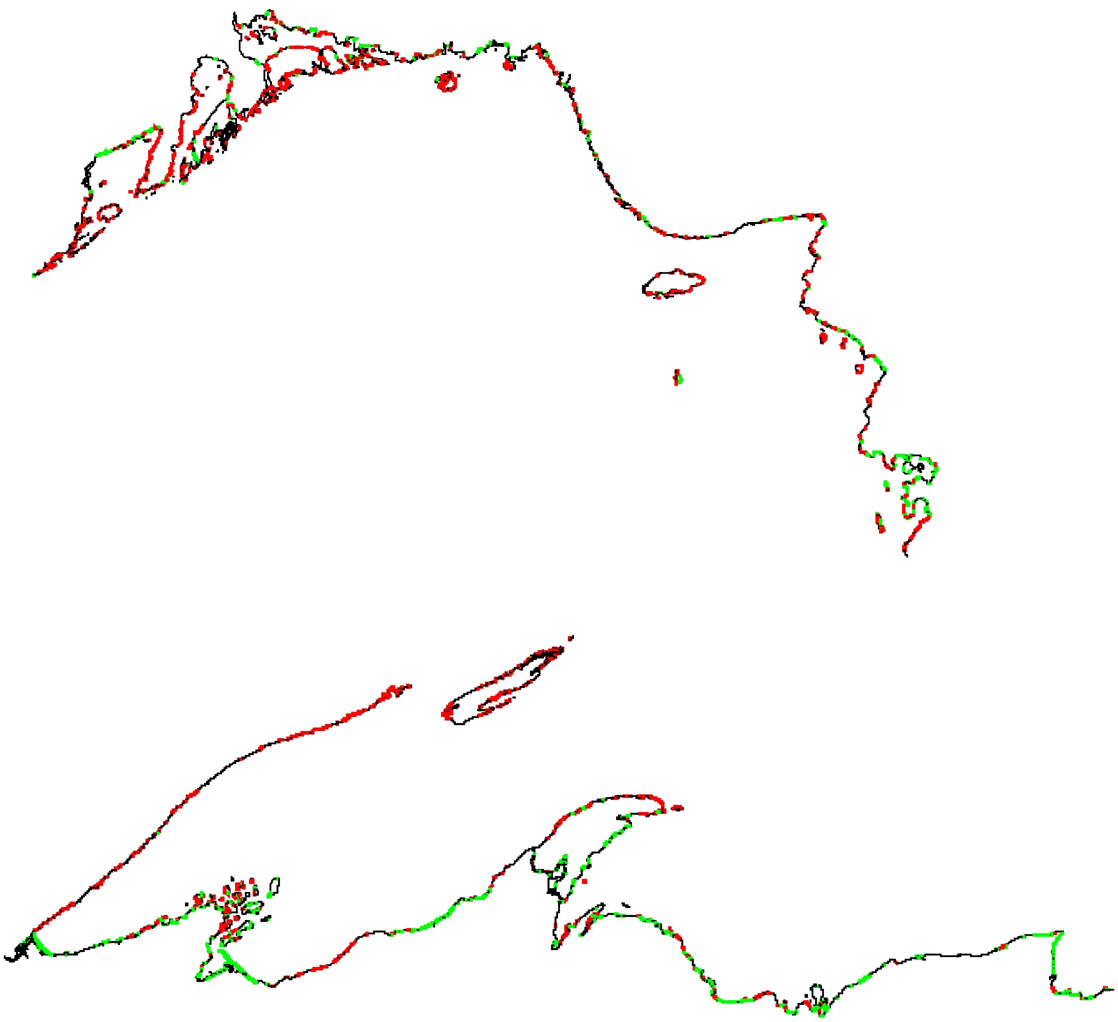


Figure 6-55 Sand (green) and cobble / gravel (red) beaches (compiled from U.S. EPA 1994 and Environment Canada 1993)

Most sand beaches depend on the natural processes of erosion, longshore sediment transport and sand deposition. When groins and other artificial shoreline structures interrupt these processes, the beach habitat is altered. Specialized beach plants can be outcompeted by other species as the environment becomes more stable (Reid and Holland 1997). Increased recreational use threatens piping plover and other sensitive species on some beaches.

Cobble and Gravel Beaches

Cobble and gravel beaches are common along rocky shorelines. Cobbles are rock chunks made up of limestone or other durable rock. Little vegetation is present due to exposure to severe wave and ice action and lack of soil. Great Lakes cobble / gravel beaches are considered to be globally rare by the Nature Conservancy (Addendum 6-B).

Cobble and gravel beaches are most common along the Minnesota north shore, Isle Royale, the Keweenaw Peninsula, the Sibley Peninsula, and islands along the Ontario coast (Figure 6-55). These beaches make up 958 km of the Lake Superior shore (Canada 541 km - includes “cobble”, “pebble” and “pebble and cobble” classes; US 417 km - includes “gravel” class)

Arctic-Alpine Communities

Arctic-alpine disjunct communities consist of plants that are isolated from their primary range in the far north or in alpine tundra. These communities are associated with the cold rocky shores of Lake Superior, where they have persisted since the retreat of the Wisconsin glacier.

Typical species include yarrow (*Achillea millefolia*), bearberry (Arctostaphylos uva-ursi), bluejoint grass (*Calamagrostis canadensis*), rocky mountain fescue (*Festuca saximontana*) and spreading juniper (*Juniperus horizontalis*). Other arctic-alpine disjunct species include mountain avens (Dryas drummondii), alpine chickweed (*Cerastium alpinum*), rock cranberry (Vaccinium vitis-idaea), butterwort (Pinguicula vulgaris), onion and garlic (Allium schoenoprasum var. sibericum), Norwegian whitlow grass (Draba norvegica), northern eyebright (Euphrasia husoniana), and alpine bistwort (Polygonum vivifarum) (Bakowsky 1998, Reid and Holland 1997). Over 400 species of lichen are associated with this environment . Two lichen species, Coccocarpia cronia and Umbilicaria torrefacta, are found only on the Susie Islands in western Lake Superior (Reid and Holland 1997).

Arctic alpine communities are usually associated with base-rich rocks such as basalt or diabase (Bakowsky 1998). Some of the best examples can be found at Sleeping Giant Provincial Park Ontario, the Slate Islands Ontario, the Susie Islands Minnesota, and Passage Island Michigan (Bakowsky 1998, Givens and Soper 1981, Judziewicz 1997).

Glaciere talus is another environment supporting arctic-alpine flora (Bakowsky 1996). This community is known from two canyons near Thunder Bay, Ontario. The steep walls block sun from reaching the canyon floor and allow ice to persist beneath talus boulders for most of the summer. The cold microclimate allows a number of arctic-alpine species to persist.

Arctic-alpine disjunct communities are generally protected from disturbance because they are inaccessible, but second-home development, recreational use, and trampling of vegetation have the potential for significant vegetative impact (Reid and Holland 1997).

Pine Barrens

Pine barrens are defined as areas of deep sands with scattered, pine trees and a ground layer of sedges and forbs. They have poor, sandy soils and frequent fires (Reid and Holland 1997). The flora often includes prairie species. Pine barrens are closely associated with oak barrens, sand barrens, savannahs, dunes, and prairies.

In the Lake Superior basin, pine barrens are found in the Bayfield Barrens Subsection (X.1) (Figure 6-24). This subsection covers 5,546 km^2 in Minnesota and Wisconsin, but pine barren makes up only a portion of the area. Soils are sandy glacial outwash (Albert 1995).

Pine barren vegetation consists of jack pine, red pine, junipers (Juniperus communis), shrubs such as sand cherry (Prunus pumila), little bluestem (*Schizachyrium scoparium*) and other grasses, sedges and forbs.

Less than 1 percent of northern Wisconsin's jack pine barrens remain today (Reid and Holland 1997). Large areas are managed as jack pine plantations for pulpwood. Fire suppression has allowed non-native species to invade and permitted the forest to succeed to more closed conditions. Recreational development is another threat (Albert 1995).

6.1.11 Other Important Species

6.1.11.1 Wild Rice

The "wild rice bowl" extends from Manitoba, through northwestern Ontario, Minnesota, and Wisconsin (Figure 6-56). Some populations in Ontario were probably introduced by native peoples many years ago (Aiken and others 1988). There have been more recent introductions to several locations in the eastern part of the Basin.

Wild rice habitat is shallow water in slowly-moving streams and inlets and outlets of lakes. It does poorly in stagnant water and fast moving streams. Soft organic material is the preferred substrate.

Wild rice is important to the ecology of lakes, streams, and shallow water wetlands. It helps maintain water quality by binding loose soils, tying up nutrients, and slowing winds across shallow wetlands. Wild rice is an important habitat component for many species. It provides wildlife, particularly waterfowl, with food and cover as well as brood cover for young birds.

Unfortunately, many of the historic wild rice stands have been lost. Although a number of factors can harm rice, it is particularly sensitive to water level changes (Vennum 1988). Many lakes and rivers have been dammed, and even small water level changes can destroy wild rice habitat. A number of interagency efforts are underway to try and reverse this decline in wild rice populations. These include abundance and harvest monitoring, restoration and enhancement, and research.

Wild Rice

To Chippewa tribes around the Lake Superior basin, wild rice (*manoomin*) is "the food that grows on water." It fulfilled a prophesy in the story of the Chippewa tribe's migration from the east – they would know that they had found their new home when they found the food growing on water. Wild rice has been a vital part of Chippewa culture and religion ever since. It was also significant in the lives of the Dakota and Menominee tribes, and provided food for early European explorers.

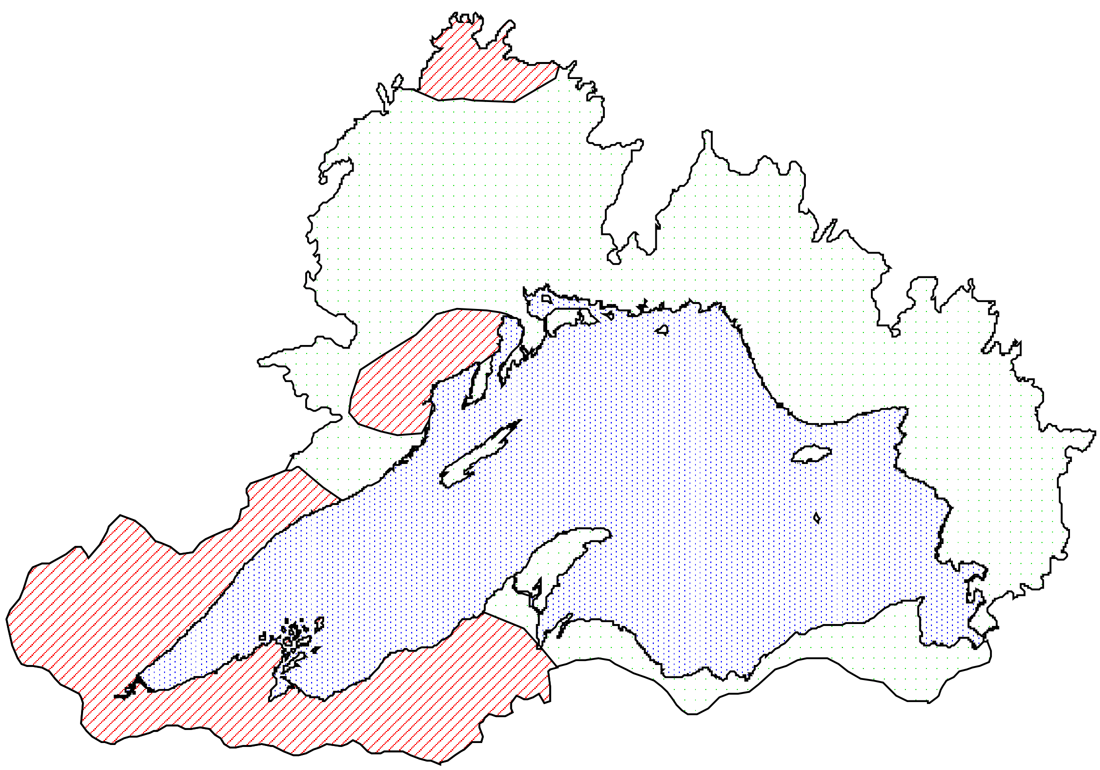


Figure 6-56. Distribution of wild rice in the Lake Superior basin (Based on Aitken and others 1988, Voss 1972)

6.1.11.2 Walleye

Historically, walleye was an important member of shallow-water (<3 m) fish communities in large bays, estuaries and tributaries of Lake Superior (Hoffe and Bronte 2000). Walleye have been caught in at least 73 Lake Superior tributaries since 1950, and spawning has been documented at 33 areas. During the late 1800s and first half of this century, walleye populations declined due to habitat degradation and overharvest (Hoff 1996). Walleye habitats in Lake Superior have been impaired by:

- reduction or elimination of fish passage in spawning tributaries,
- reduction in water quality caused by sedimentation and discharge of contaminants into the lake, and
- degradation of spawning and nursery habitats in six areas.

Six bays and ten rivers have been identified where walleye populations and/or habitats are in need of rehabilitation. The status of walleye habitat in Lake Superior and spawning tributaries is summarized below by jurisdiction.

Most walleye in the Minnesota waters of Lake Superior spawn within the 22 miles stretch of the St Louis River, below the hydroelectric dam near the village of Fond du Lac (Geving and others 1999). Spawning and nursery habitats in the St. Louis River have been negatively impacted since the turn of the century by water pollution from the upstream discharge of untreated domestic and industrial waste. In particular, chorophenolics and choro-organics from pulp and paper mills caused oxygen deficiencies and reduced the palatability in walleye (Schram and others 1999). Improvements in waste treatment initiated by the Western Lake Superior Sanitary District in 1978 has curtailed obvious widespread habitat degradation caused by inadequately treated organic compounds and biological oxygen demand. It has also dramatically improved walleye palatability and consequently, angling pressure. Persistent toxic contaminants remain a problem in walleye in the St. Louis River however, and further water quality improvements in the St. Louis River basin has been recommended to enhance walleye populations (Geving and others 1999). Key spawning areas in the St. Louis River are strongly influenced by manipulated water levels caused by hydroelectric dam operations. Fish kills and stranding of spawning walleye have been caused by bypassing water from the natural river channels to hydroelectric plants or from shutting down flows to recharge reservoirs. Recent licenses for dam operations have stipulated more favorable flow regimes, thereby increasing available walleye habitat.
The protection and enhancement of shallow nursery habitats within the St Louis River estuary has been aided by the purchase of waterfront property adjacent to the main spawning area by the Wisconsin DNR (Schram and others 1991).

In Wisconsin, there were historically three separate spawning populations:

- western lake Superior stocks that spawned primarily in the St. Louis River,
- Chequamegon Bay stocks that primarily spawn in the Kakagon River,
- Bad River spawning population (Schram and others 1999).

Poor forestry and agricultural practices (e.g. management of livestock and associated wastes) in the Bad River watershed have degraded riparian habitats and increased sedimentation at some locations, and contributed to increased flooding and reduced water quality. Contaminants may also have negatively affected spawning walleye populations in the Bad River (Schram and others 1999) and consumption advisories remain for both the Kakagon and Bad Rivers.

Habitat for four of the five major walleye populations in Michigan waters of Lake Superior has been impacted. The Victoria Dam and Bond Falls Dam have impeded upstream migration to traditional spawning areas in the Ontonagon River. Peak flows from hydroelectric facilities at those dams have also caused bank erosion. Development, poor land use practices (e.g. logging), and poorly constructed road crossings have increased bank erosion and sedimentation, and likely affected spawning habitats and wetlands throughout the Ontonagon River, the Huron Bay Watershed (Silver, Ravine, and Slate rivers), and the lower Tahquamenon River. Sedimentation and loss of vegetation due to winter navigation and shipping have negatively affected walleye spawning and nursery habitat in the upper St Marys River. Habitat loss from past logging-related shipping has also occurred in Sherman Park, Izaak Walton Bay, Cedar Point and Waishkey Bay (Hoff and others 1999). Habitat degradation does not appear to be significantly impacting the other major Michigan populations, Lac La Belle.

Black Bay and Nipigon Bay in Ontario historically had the largest population of walleye in Lake Superior, and Thunder Bay and Whitefish Bay also supported large fisheries (Ryder 1968; Schneider and Leach 1977; Kelso and others 1996). Impaired water quality from paper mill effluent downstream of spawning areas on the Nipigon River has been identified as a major cause in the decline of the Nipigon Bay population in the 1960s (Ryder 1968), although overfishing is also thought to have contributed (MacCallum and Selgeby 1987). Electrical barriers operated by the Sea Lamprey Control Centre during the 1950s and 1960s caused direct mortality of walleye in Lake Superior tributaries (including the Jackfish River) and prevented upstream migration to spawning grounds (Schram and others 1999). The Goulais Bay and Goulais River of the Whitefish Bay area, supported a commercial walleye fishery until the mid 1960s. Current use of TFB-Bayer 73 lampricide treatments and low alkalinities in spawning areas are thought to be reducing survival of walleye eggs and larvae (Rose and Kruppert 1984). Hydroelectric dams on the Michipocoten and Magpie rivers have restricted access to upstream spawning grounds. Habitat loss along the shoreline within the city of Thunder Bay may be limiting walleye stocks (Schram and others 1991). Concentrations of persistent toxic chemicals in walleyes from Goulais, Batchawana, and Nipigon bays remain above consumption advisories so further rehabilitation of water and sediment quality in walleye habitats is needed.

The Walleye Subcommittee of the Lake Superior Technical Committee has reported on the status of walleye populations (Hoff 1996) and drafted rehabilitation plan (Hoffe 1999). They recommend that:

> *The Lake Superior fish community will be managed to maintain, enhance, and rehabilitate habitat for, and self-sustaining populations of, walleye in areas where the species historically maintained populations.*

Objectives for rehabilitation of walleye habitats included (Hoff 1999):

- creating or maintaining spawning and nursery habitats (St. Marys River, Ontonagon River, Huron Bay Watershed, Bad River),
- enhancing fish passage pas a dam in the Ontonagon River,
- reducing sedimentation by 50 percent in the St Marys River, Tahquamenon River, and the Huron Bay Watershed,
- eliminate point source discharge of persistent toxic chemicals into the lake to reduce contaminant concentrations in walleyes, and
- improve land and water use practices in the St Marys River, Ontonagon River, Huron Bay Watershed, and the Bad River.

6.1.11.3 Coaster Brook Trout

Coaster brook trout are a large form of anadromous or lake dwelling brook trout (*Salvelinus fontinalis*) spend at least part of their life in Lake Superior (Becker 1983). They were historically common and widespread in the nearshore waters of Lake Superior and were often referred to as “coasters” or “rock trout” because of their preference for rocky, shallow coastal areas. Coaster brook trout typically spawn in tributaries in the fall before returning to the lake; fry remain in-stream during early development before descending to the lake. Shoal spawning coasters may spend their entire life cycle in Lake Superior, whereas others make many movements between stream and lake habitats (Newman and others 1998).

There is little information on Lake Superior brook trout before 1900 because early catch records did not distinguish brook trout from lake trout. In the early 1800s, lake-dwelling brook trout were found in most Lake Superior waters within 50 feet of shore, or about islets and shoals close to shore (Shiras 1935). They were less common along sandy beaches and steep, wave-washed cliffs. Coasters historically spawned in at least 106 Lake Superior tributaries, including 61 in Ontario, 25 in Michigan, 12 in Wisconsin and nine in Minnesota. They were probably present below the first barrier in all streams along Lake Superior's north shore (Waters 1983) and most coldwater streams along the south shore.

Overexploitation, particularly by anglers, is considered the primary cause for the abrupt decline of coaster brook trout populations after the 1860s. Brook trout are very vulnerable to angling, and coasters particularly so because they inhabit shallow shoreline areas and congregate at stream mouths for feeding and spawning. Incidental catch of brook trout in nearshore gill nets increased as fishing effort for lake trout and whitefish expanded in the early 1900s. In some areas, spawning fish were netted at stream mouths, which led to extirpation of local populations (Newman and Dubois 1997). During the late 1800s and early 1900s, anglers from across North America fished for large brook trout in Lake Superior's waters and tributaries, particularly the Nipigon, St. Mary's, Bois Brule and Salmon Trout rivers (Newman and Dubois 1997). By the early to mid 1900s, coaster brook trout were reduced to the small, scattered populations which have persisted in less accessible areas.

Habitat loss contributed to the decline in coaster populations and may be responsible for suppressing the recovery of stocks. Most destruction of habitat resulted from logging in the Lake Superior watershed, which accelerated in late 1800s. Critical spawning areas were degraded by sedimentation from increased erosion and deposition of bark debris from log drives. Coarse woody material essential for fish habitat was removed from stream banks and bottoms during log drives. Elimination of riparian cover, clear-cutting of watersheds and resulting wildfires may have increased water temperatures and affected groundwater movement. Finally, dam construction blocked migration routes and altered natural stream flow, sometimes resulting in exposure of eggs during draw down for hydroelectric production (Newman and Dubois 1997). At about the same time, introduction of non-native salmonids such as the rainbow trout, brown trout, coho salmon and chinook salmon may have represented an additional stress.

Assessment of the current distribution and abundance of coaster brook trout is difficult due to the presence of introduced hatchery fish and incidental occurrence of non-migratory stream fish. Interbreeding with domestic strains of brook trout may also have altered the genetic composition of native brook trout and reduced their migratory tendency (Newman and Dubois 1997). Coaster brook trout now persist as scattered remnant populations and have been eliminated from many areas, especially along the south shore of the lake. They persist where there is suitable habitat and some measure of protection from overexploitation by angling.

In Ontario, small numbers of coaster brook trout are caught at numerous locations in the lake and in many tributaries. The most important remaining spawning location is the Nipigon River (Newman and Dubois 1997) which may offer some degree of protection from overharvest due to its large water volume and flow. The relatively remote Cypress, Gravel and Little Gravel River also support consistent spawning runs. A number of shoal-spawning coaster brook trout populations persist near Isle Royale, as well as stream spawning stocks in Washington and Grace Creeks. Coaster brook trout numbers are occasionally reported at numerous locations along the south shore of Lake Superior, but abundance is considered very low. In mainland Michigan, only the privately managed Salmon Trout River still has a spawning run of coaster brook trout, and that population may be imperiled. In Minnesota, the Little Marais River may have spawning coaster brook trout, and reintroduced coaster brook trout appear to be spawning in two tributary streams on the Grand Portage Indian Reservation. No reproducing coaster populations are known from Wisconsin.

Recovery efforts for Lake Superior coaster populations have focused on identifying, protecting, and rehabilitating historical spawning streams. Efforts involve angling regulation (seasons, bag limits, size restrictions) and water level regulation (Newman and others 1998). Stocking brook trout in U.S. waters of Lake Superior has taken place since at least the 1940's, but return rates have been low and no natural reproduction has been recorded. Stocking of Nipigon Bay on the Canadian side has not been extensive and is poorly documented. A number of Nipigon Bay tributaries were stocked in the early 1980s (Cullis and others 1991). Invariably, brood stock has originated from Lake Nipigon or other sources, rather than native Lake Superior strains. Attempts are currently underway in Michigan to establish native Isle Royale hatchery stock (Newman and Dubois 1997).

6.1.11.4 Lake Trout

Lake trout were historically the dominant predator in Lake Superior until the 1950s, when they declined rapidly due to commercial fishing pressure and sea lamprey predation (Hansen 1994). Lake trout numbers are dependent on a complex combination of fishing pressure, prey abundance, competition with introduced salmonids and other species, stocking, and predation, especially by sea lamprey. Figure 6-57 shows commercial fisheries management units in Lake Superior. Despite stocking efforts, lake trout populations have not recovered to historical levels. With a few exceptions, habitat loss and degradation is not considered a major factor in lake trout decline, nor as a limiting factor for their recovery.

Lake trout are well adapted to cold, clear, oligotrophic condition and most of offshore and nearshore areas of Lake Superior comprises important habitat for lake trout at some life stage. Lake trout historically spawned at an estimated 337 sites in the main basin of Lake Superior, of which 210 were along the mainland and 127 offshore or along island shorelines (Table 6-27).

Approximately one-half of the total sites were in Canadian waters, with a greater proportion of the offshore sites. Lake trout typically spawn over coarse substrates (e.g. boulder and cobble) with little or no fine material on offshore reefs and shoals or on points extending into deep water (Marsden and others 1995). In Minnesota, shallow water habitats (<20 m) had a greater proportion of good spawning habitat with coarse substrate than deeper habitats which tended to have more fine materials (Richards and others 1999).

Lake Superior lake trout consist of a number of reproductively isolated stocks distinguished from each other by differences in the shape of the snout, body shape, coloration, fat content, size of the eye, and thickness of the abdominal wall. Although up to 12 variants have been identified, three main forms are recognised, leans, siscowets, and humpers (Goodier 1981).

Lean lake trout typically inhabit nearshore waters less than 80 m deep, shallow offshore reefs, and the nearshore waters around the islands in Lake Superior. Lean lake trout spawning grounds are found in both nearshore and offshore areas in <80 m of water. Approximately 23 percent or 1.9 million ha of Lake Superior is less than about 80 m deep, but in U.S. waters only 12 percent of the area <40 fa should be considered as lean lake trout spawning habitat (Ebener 1998). A similar proportion may be suitable in Canadian waters. Lean lake trout spawn offshore at the Gull Islands, Superior Shoal Stannard Rock, Caribou Island, Michipicoten Bay, and the area north of Whitefish Bay.

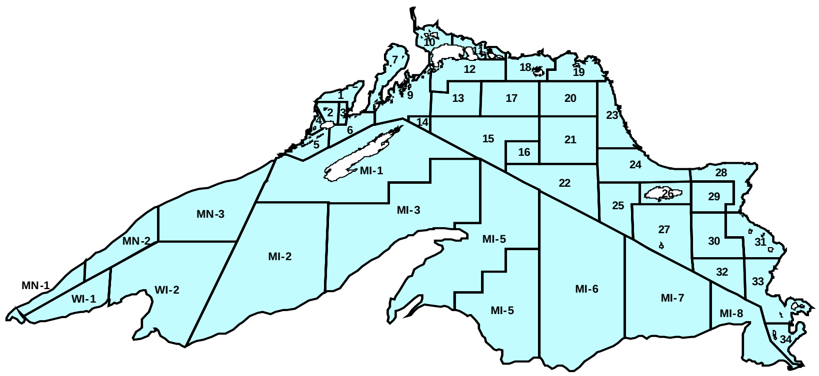


Figure 6-57. Commercial fisheries

Nearshore spawning habitats in most of the lake are associated with the main shoreline, with the exception of Wisconsin where almost all lean lake trout spawning habitat in the nearshore zone is located along the outer periphery of the Apostle Islands since most of the mainland shore is sand or clay and (MacCallum and Selgeby 1987). The Gull-Michigan Island Reef, approximately 30 km offshore is the main site of wild reproduction in Wisconsin, although limited natural reproduction occurs at numerous other locations in Wisconsin (Swanson and Swedberg 1980).

Lean lake trout spawning habitat in harbours-bays-estuaries is found in Keweenaw, Whitefish, Thunder, and Nipigon bays as well. Lean lake trout historically spawned in nine tributaries in eastern Lake Superior (Goodier 1981; Ebener 1998) from the Steel to Montreal rivers. Wild lean lake trout have been recently found in spawning condition inside the mouths of the Montreal and Dog rivers, but spawning has not been confirmed (Ebener 1998). Lake trout also use these rivers during the non-spawning season.

Siscowets usually are found in deep (50-150 m), offshore waters, but they are also abundant in nearshore waters. All water <50 fa, and much that is deeper, is considered spawning habitat for siscowets. They spawn in deep water around offshore reefs. Siscowets appear to be more abundant in nearshore areas relative to lean lake trout than was observed in the past.

Humpers are less common and live predominately on isolated shoals surrounded by deep waters around Isle Royale and in eastern waters of the lake around Caribou Island (Hansen 1996). They spawn at the most of the same offshore sites as leans, with the potential exception of Stannard Rock.

Table 6-27 summarizes critical and important habitats for leans, siscowets and humpers (Ebener 1998). Most of the identified important habitat is in offshore areas such as Superior Shoal, Caribou Island, Isle Royale and Stannard Rock where remnant stocks of native lake trout persisted. Offshore habitats were critical since abundance, especially of mature wild fish never fell as low as it did in the inshore region (MacCallum and Selgeby 1987). Stocks of lean lake trout occupying many offshore reefs or shoals are probably genetically distinct (Ebener 1998). In addition, they are less vulnerable to impacts from human activities than nearshore areas. Although much of the focus has been on spawning sites, optimal habitat for other life history stages of lake trout is also essential. However, the distribution of larval lake trout in Lake Superior is too poorly known to accurately quantify nursery habitat for lake trout. It estimated that about 40 percent of the waters less than 50 fa would be suitable nursery habitat for lean lake trout.

Table 6-27 Critical and important habitat in Lake Superior for lake trout

STRAIN	LIFE STAGE	IMPORTANT HABITAT	CRITICAL HABITAT
Offshore(>80 m)			
lean	juvenile	all water <91 m	Stannard Rk. , Superior Sh., Caribou I.
	non-spawning adult	all water <146 m	Stannard Rk. , Superior Sh., Caribou I.
siscowet	egg	all water > 110 m	unknown
	juvenile	all water 80-128 m	none
	non-spawning adult	all water >110 m	none
	spawning adult	all water >110 m	unknown
humper	egg	rock substrate <60 m in offshore areas	Caribou I., Isle Royale, Superior Sh.
	juvenile	unknown	none
	non-spawning adult	unknown	none
	spawning adult	rock substrate <60 m in offshore areas	Caribou I., Isle Royale, Superior Sh.

Table 6-27 Critical and important habitat in Lake Superior for lake trout

STRAIN	LIFE STAGE	IMPORTANT HABITAT	CRITICAL HABITAT
Nearshore (<80 m)			
lean	egg	rock substrates 0.5-30 m	rock substrates 0.5-30 m, DO>6mg/l
	juvenile	all water 35-80 m	none
	non-spawning adult	all water 35-80 m	none
	spawning adult	rock areas 0.5-30 m	rock substrates 0.5-30 m
siscowet	egg	unknown	unknown
	juvenile	all water <80 m	none
	non-spawning adult	water 36-80 m	none
	spawning adult	unknown, probably very little	unknown
humper	egg	rock substrate <60 m	water <60 m Caribou I., Isle Royale, Superior Sh.
	juvenile	offshore banks Isle Royale, Caribou Is.	none
	non-spawning adult	offshore banks Isle Royale, Caribou Is.	none
	spawning adult	rock substrate < 60 m	water <60 m Caribou I., Isle Royale, Superior Sh.
Tributaries			
lean	egg	eastern Lake Superior tributaries	Montreal & Dog (University) rivers
	juvenile	eastern Lake Superior tributaries	Montreal & Dog (University) rivers

However, the effects have not been thoroughly evaluated in Lake Superior fish. Lake trout habitat can be adversely affected by toxic pollutants, poor water quality, watershed misuse, sedimentation, eutrophication, and residential and commercial development (Hansen 1996). Industrial pollution in the form of low-level contamination by organic pollutants and metals may have had effects on the health and reproduction of lake trout (especially fatty siscowets) (Busiahn 1990), however, the effects have not been thoroughly evaluated in Lake Superior fishes. Relatively shallow water directly adjacent to the shore is important as potential spawning areas for lake trout but such areas are frequently impacted by upland land uses (Richards and others 1999), at least on the American side. Wood fibre effluent from a mill negatively impacts of lake trout spawning grounds in Terrace Bay and mine tailing at the North & South degrade lake trout habitat (Ebener 1998). The Montreal river population of lake trout may currently be limited by habitat due to fluctuating water levels caused by a hydroelectric facility (Ebener 1998).

The Lake Trout Restoration Plan for Lake Superior (Hansen 1996) recommended that an atlas of lake trout spawning grounds be developed. General locations of lake trout spawning habitats were mapped by Coberly and others (1980), Goodier (1981), and Goodyear and others (1981) but need to be ground-truthed. Habitat that is essential for lake trout reproduction and survival should be identified, mapped and protected (Busiahn 1990). Progress has been made in Minnesota, where lake trout spawning habitat along 65 km^2 of waters less than 30 m deep Minnesota's North Shore has been surveyed using remote hydro-acoustic techniques coupled with a GPS and GIS (Richards and others 1999).

Number of spawning sites taken from Coberly and Horrall (1980), Goodyear and others (1981) and Goodier (1981) and includes present day as well as historically important areas. Spawning habitat is considered to be <5 fa deep. Average CPUE, wild fish, and mortality for U. S. and Canadian waters adjusted for area <40 fa and <50 fa deep, respectively.

Table 6-28 Estimated quantity of total, spawning, and nursery habitat, and biological parameters for lake trout in each management unit in Lake Superior

Mgt unit	Total habitat (ha)		No. spawning sites		Spawning habitat		Nursery habitat		Biological parameters			
									Years	Survey CPUE[3]	Wild fish[4] (%)	Annual mortality[5] (%)
	total	<40 fa[1]	onshore	offshore	(ha)	% area[2]	(ha)	% area[2]				
MI-1	573,003	49,645	18	2	13,600	27	1,200	2	1993-95	16	98	29
MI-2	636,599	87,786	7	0	4800	5	1,200	1	1996	34	87	45
MI-3	620,654	64,674	10	0	4625	7	1,200	2	1996	7	91	41
MI-4	622,657	132,146	15	7	15,213	12	2,300	2	1996	14	88	51
MI-5	367,935	76,385	13	0	4,290	6	14,500	19	1996	32	83	42
MI-6	761,196	74,934	7	3	36,600	49	71,500	95	1996	45	90	58
MI-7	411,881	81,697	1	5	31,300	38	42,800	52	1996	18	94	54
MI-8	179,626	176,868	2	1	14,300	8	40,100	23	1996	10	17	68
WI-1	107,408	48,513	1	0	12	0	0	0	1995 & 97	20	42	36
WI-2	400,703	231,797	12	23	7,773	3	266,131	115	1995 & 97	18	71	37
MN-1	107,723	57,185	8	0	5,700	10	1,190	2	1996	34	45	45
MN-2	173,567	7,955	9	0	400	5	430	5	1996	7	20	40
MN-3	358,789	14,899	21	0	1,200	8	4,500	30	1996	26	70	45
Subtot.	5,321,741	1,104,485	124	41	139,813	13	447,051	40	1993-97	21	69	48
1	33,366	33,046	4	2					1992-96	90		<45
2	22,451	22,440	0	4					1992-96	47		<45
3	10,922	9,765	1	1					1992-96	100		<45
4	13,871	13,871	3	3					1992-96	44		
5	41,614	25,361	5	1						22		
6	46,285	5,875	3	2					1992-96	46		
7	60,139	60,139	2	0					1992-96	16		
8	4,431	3,409										
9	101,191	28,759	11	3					1992-96	37		
10	39,818	39,818	3	6								
11	35,627	31,229	1	6					1992-96	34		
12	105,284	14,218	0	10					1992-96	36		
13	91,264	0										
14	27,415	2,784	0	3					1992-96	185		

Table 6-28 Estimated quantity of total, spawning, and nursery habitat, and biological parameters for lake trout in each management unit in Lake Superior

Mgt unit	Total habitat (ha)		No. spawning sites		Spawning habitat		Nursery habitat		Biological parameters			
									Years	Survey CPUE[3]	Wild fish[4] (%)	Annual mortality[5] (%)
	total	<40 fa[1]	onshore	offshore	(ha)	% area[2]	(ha)	% area[2]				
15	209,058	0										
16	45632	2,192	0	4					1992-96	318		
17	119784	919										
18	67,572	17,485	9	8						110		
19	72,227	26,510	9	0					1992-96	27		
20	119,784	13,209										
21	159,712	23										
22	204,436	0										
23	99,844	10,240	8	0					1992-96	68		<45
24	137,912	26,158	5	0					1992-96	51		<45
25	109,766	6,347										
26	49,287	15,657	0	15						291		
27	182,150	57,232	0	3					1992-96	270		
28	88,909	43,661	10	0					1992-96	52		23
29	79,856	10,681	0	0						280		
30	114,080	0	0	0					1992-96	229		<45
31	90,303	51,997	2	11					1987-92	11	45	42
32	77,099	2,552	0	0					1992-96	273		<45
33	131,729	90,707	4	3					1987-92	8	35	69
34	47,452	44,409	6	1					1987-92	7	2	63
Subtot	2,840,270	710,693	86	86	0	0	0	0	1992-96	61		<45
Total	**8,162,011**	**1,815,178**	**210**	**127**	**139,813**	**0**	**447,051**	**0**				

[1]Canadian waters is < 50 fa deep
[2]Percent of areas < 40 fa deep in U. S. waters
[3]CPUE is fish per 1,000 ft. of survey gill net in U. S. waters and in Canada CPUE is based on commercial catches and expressed as kg/km
[4]In MN-1, MN-2, and MN-2 is percent of fish ≤635 mm total length.
[5]Mortality rates are for ages 5-9 in 1996-97 for MI-8, whereas ages 9-12 MI-3 through MI-7.

6.1.11.5 Lake Whitefish

Lake whitefish are not generally habitat-limited in Lake Superior. Lake whitefish spawn on sand, gravel and rock substrates in 2-23 m (usually <5m) of water from late October to early December at water temperatures of 0.5-5.5°C (Ebener 1998). Upon hatching in the spring, the pelagic larvae float with the currents and often accumulate in embayments (Reckahn 1970). During the first summer, young lake whitefish (age-0) are believed to be associated with the 17°C isotherm in bays and estuaries until they switch from a planktivorous to a benthic diet and move to colder and deeper water in the fall. Juvenile and adult lake trout feed primarily on feeding on benthic invertebrates over soft bottom areas (primarily sand and silt) from the nearshore to offshore waters <73 m deep. Adult lake whitefish often return to shallower waters in the spring to feed on emerging mayflies (Goodier 1982). Most adult whitefish remain within 40 km of natal spawning grounds, which has led to the differentiation of semi-discrete stocks (Lawrie and Rahrer 1973).

Coberly and Horrall (1980), Goodier (1981) and Goodyear and others (1981) have summarized the general location of lake whitefish spawning grounds in Lake Superior. These areas are considered critical spawning habitat, and are generally restricted to nearshore and harbour-bays-estuaries habitats. Current whitefish spawning grounds are located in the Apostle Islands, along the Keweenaw Peninsula, and in Whitefish Bay. Lake whitefish spawn off Isle Royale but there is very little whitefish spawning habitat in western Wisconsin waters, Minnesota waters and along the northeastern Canadian shoreline.

Approximately 123,000 ha or 11 percent of the water <40 fa deep is considered lake whitefish spawning habitat. As much as 300,000 ha of suitable lake whitefish nursery habitat may be available in Lake Superior, but this estimate is very unreliable (Ebener 1998). Lake whitefish historically spawned at 106 sites, 60 of which were in nearshore areas and the remainder on the outside of islands. Ten sites were located in harbour-bays-estuaries habitats. Most (90) sites were in U.S. waters. Lake whitefish historically spawned in the St. Louis estuary, the Michipicoten, White, University (Dog) and Kaminstiquia rivers, and St. Mary's River above the rapids (Lawrie and Rahrere 1972, Goodier 1982). Spawning populations are still known from the Anna River near Munising (Ebener 1998).

Nearshore habitat bordered by beaches and sandy bays are critical both as spawning habitat and food sources for adults. These areas require protection from dredging, shoreline development, contaminants, and localized increase in nutrients. Illegal dredging of spawning grounds in Whitefish Bay negatively affects lake whitefish eggs. Mine tailing from the North and South Entry negatively impact lake whitefish populations. Lake whitefish have been reported to contain a wide variety of organic and metallic contaminants, such as PCBs in whitefish from Peninsula Harbour near Marathon (ULRG 1977). Lake whitefish habitat has been degraded by the deposition of woody debris in rivers and nearshore areas. The lake whitefish stock that historically spawned in the St. Louis estuary was extirpated in the late 1800s because of habitat destruction. Dredging and dumping of grain screening degraded spawning grounds in the Kaministiquia River (Goodier 1982). Fish community objectives for Lake Superior include restoring the presence of lake whitefish to historic spawning sites in the lake and historic spawning tributaries (Ebener 1998).

Number of spawning sites taken from Coberly and Horrall (1980), Goodyear and others (1981) and includes present day as well as historically important areas. Spawning habitat is considered to be <5 fa deep. Average CPUE and mortality in U. S. and Canadian waters adjusted for area <40 fa and <50 fa deep, respectively.

Table 6-29. Estimated quantity of total, spawning, and nursery habitat, and biological parameters for lake whitefish in each management of Lake Superior

Mgt unit	Total habitat (ha)		No. spawning sites		Spawning habitat		Nursery habitat		Biological parameters		
									Years	CPUE[1]	Annual mortality
	total	<40 fa[1]	on shore	off shore	(ha)	% area[2]	(ha)	% area[2]			
MI-1	573,003	49,645	9	0	628	1			1978-81		55
MI-2	636,599	87,786	0	0	300	0	700	1	1996	160	45
MI-3	620,654	64,674	7	0	400	1	600	1	1996	130	78
MI-4	622,657	132,146	14	2	500	0	800	1	1996	72	73
MI-5	367,935	76,385	2	1	18,600	24	4,700	6	1994-96	71	30
MI-6	761,196	74,934	9	0	52,500	70	37,000	49	1996	57	50
MI-7	411,881	81,697	1	0	13,000	16	20,000	24	1996	156	53
MI-8	179,626	176,868	6	0	25,500	14	39,500	22	1996	93	57
WI-1	107,408	48,513	2	0	162	0	0	0		20	
WI-2	400,703	231,797	4	35	8,500	4	187,023	81	1996	126	73
MN-1	107,723	57,185	0	0	0	0	0	0			
MN-2	173,567	7,955	5	0	0	0	7,955	100			
MN-3	358,789	14,899	2	0	3,000	20	0	0			
Subtot.	5,321,741	1,104,485	61	38	123,090	11	298,278	27		104	63
1	33,366	33,046	1	0					1992-96	427	<45
2	22,451	22,440	1	0					1992-96	184	
3	10,922	9,765							1992-96	102	
4	13,871	13,871							1992-96	132	
5	41,614	25,361							1992-96	129	
6	46,285	5,875							1992-96	88	
7	60,139	60,139							1992-96	88	<45
8	4,431	3,409									
9	101,191	28,759							1992-96	140	
10	39,818	39,818									
11	35,627	31,229							1992-96	74	
12	105,284	14,218							1992-96	200	
13	91,264	0									
14	27,415	2,784							1992-96	5	
15	209,058	0									
16	45,632	2,192							1992-96	0	
17	119,784	919									
18	67,572	17,485							1992-96	59	
19	72,227	26,510							1992-96	79	
20	119,784	13,209									
21	159,712	23									
22	204,436	0									
23	99,844	10,240							1992-96	143	<45
24	137,912	26,158							1992-96	76	<45
25	109,766	6,347									

Table 6-29. Estimated quantity of total, spawning, and nursery habitat, and biological parameters for lake whitefish in each management of Lake Superior

Mgt unit	Total habitat (ha)		No. spawning sites		Spawning habitat		Nursery habitat		Biological parameters		
									Years	CPUE[1]	Annual mortality
	total	<40 fa[1]	on shore	off shore	(ha)	% area[2]	(ha)	% area[2]			
26	49,287	15,657							1992-96	109	
27	182,150	57,232									
28	88,909	43,661							1992-96	152	<45
29	79,856	10,681									
30	114,080	0									
31	90,303	51,997							1992-96	108	68
32	77,099	2,552									
33	131,729	90,707	2	1					1992-96	99	39
34	47,452	44,409	1	1					1992-96	151	36
Subtot.	2,840,270	710,693	5	2					1992-96	131	<45
Total	8,162,011	1,815,178	66	40	123,090	0	298,278	0		114	

[1]Canadian waters is < 50 fa deep.
[2]Percent of areas < 40 fa deep in U. S. waters
[3]CPUE is expressed as kilograms per kilometer of gill net.

6.1.11.6 Woodland Caribou

Woodland caribou formerly inhabited most of the Lake Superior Basin. By the late 1800's, their numbers were declining and their range was receding northward. Caribou disappeared from the US part of the basin by the early 1940's (Hazard 1982) and they are now extirpated from Michigan, Wisconsin and Minnesota. In Ontario, the southern limit of caribou range receded from the northshore of Lake Superior in 1900 to northern Lake Nipigon at present (Figure 6-58). North of this line, caribou are more or less continuously distributed. Remnant populations are on the Slate Islands (several hundred animals), Pic Island, Neys Provincial Park, Pukaskwa National Park and Michipicoten Island (introduced) (Harris 1999). Status is under review in Ontario (Harris 1999).

Caribou range recession is due to increased human activity. Logging and human settlement caused forest fragmentation and loss of mature coniferous forest cover. Populations of moose and white-tailed deer increased with the changes in forest landscape. In Ontario, at least, wolves increased in response to the increased prey availability. Increased wolf predation, combined with increased hunting pressure, caused greater mortality for caribou. Their relatively low reproductive rate meant that caribou could not compensate for the increased mortality. Today, caribou within the Lake Superior Basin are restricted islands and other areas where they can avoid wolves, and where logging has not fragmented the landscape.

Forest management guidelines have recently been implemented in Ontario to protect caribou habitat by reducing forest fragmentation, protecting calving areas and minimizing human disturbance (Racey and others 1999).

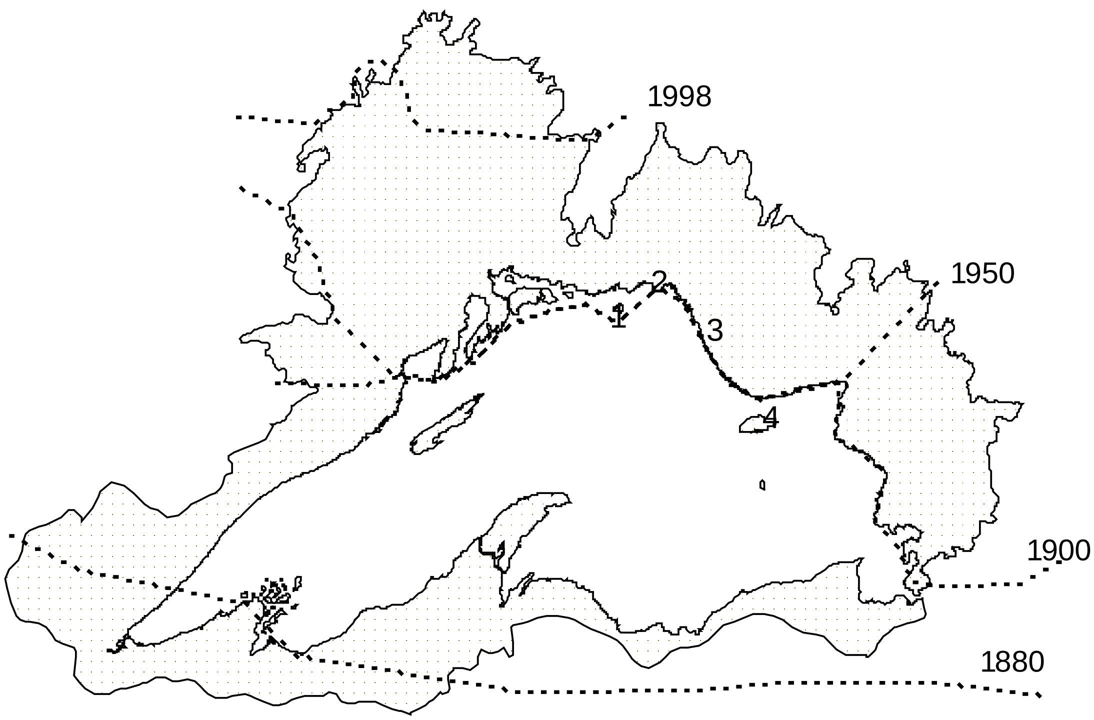


Figure 6-58. Historical and present distribution of woodland caribou in the Lake Superior basin.
Dotted lines indicate southern limits of caribou distribution at various periods. Numbers indicate remnant herds: 1 – Slate Islands, 2 – Neys, Pic Island, 3 – Pukaskwa, 4 – Michipicoten Island (adapted from Darby and others 1989 and Armstrong 1998).

6.1.11.7 Trumpeter Swan

Trumpeter swan (*Cygnus buccinator*) is Threatened in Michigan and Endangered in Wisconsin. Their historic breeding range may have included most of the Lake Superior Basin, but there is little documentation. Trumpeter swans nested in Minnesota and Wisconsin until the 1880s (WI DNR 1999b). There is no conclusive evidence that they ever nested in Ontario (Austen and others 1994).

Trumpeter swans were extirpated from much of their former range due to market hunting and the millinery trade. Restoration efforts since the late 1960’s have lead to the establishment of a several flocks.

Important habitats are large shallow water wetlands with interspersion of open water and emergent vegetation. Isolation from human disturbance is important. Rivers that maintain open water throughout the winter are critical for over-wintering flocks (WI DNR 1999b).

Habitat-related threats to restoration include draining and filling wetlands and degradation of wetland habitat by invasions of exotic species such as mute swans, carp and purple loosestrife (WI DNR 1999b). Variations in outflow from hydroelectric dams in winter may threaten overwintering birds by reducing open water habitat (WI DNR 1999b). Recovery plans are in place for Minnesota, Wisconsin, Michigan and Ontario and focus on release of captive birds (WI DNR 1999b).

6.1.11.8 Neotropical Migrant Birds

Neotropical migrant landbirds include 143 species that breed in North America and winter south of the United States (Thomson and others 1992). Approximately 70 percent of these species breed within the Lake Superior basin. Many neotropical migrant landbirds are declining markedly, and the following species have experienced the most significant declines in the basin: yellow-billed cuckoo, bank swallow, bobolink, whip-poor-will, Nashville warbler and wood thrush (Thomson and others 1992). Various factors have been implicated in the decline, including changes in forest structure in breeding habitat in North America, deforestation on neotropical wintering grounds, increased levels of brood parasitism by cowbirds (linked with habitat fragmentation) (Terborgh 1989). Many area-sensitive neotropical migrants that are found in the basin e.g., veery, black-and-white warbler, ovenbird, and northern waterthrush, are particularly vulnerable to forest fragmentation (Robbins and others 1989).

Thomson and others (1992) evaluated the status of neotropical migrants from the midwest (3 provinces and 14 states) based on breeding ground threats, population trends and the importance of the region to the species. The species of most management concern whose ranges encompass most or all of the basin included the chestnut-sided, bay-breasted, Connecticut, Nashville and Canada warblers. The Lake Superior basin represents a significant portion of the breeding habitat, and although they are still relatively common in the basin (Cadman and others 1987), their populations show a long-term decline. Current and past timber extraction may be differentially affecting the breeding success of these and other neotropical migrants. Connecticut and Nashville warblers are most abundant in mature conifer forests, whereas chestnut-sided, bay-breasted and Canada warblers commonly use younger successional hardwood and mixedwood forests, which have increased in extent within the basin. In a northern hardwood forest in New York, numbers of both chestnut-sided and Canada warblers increased in response to logging. (Webb and others1977)

Although the Lake Superior basin is not on a major migratory flyway, significant numbers of birds migrate through the basin. Lake Superior represents a considerable obstacle, so many birds follow either the eastern or western shore, or use the Slate Islands, Isle Royale, Michipicoten and Caribou islands as they hop cross from the north to south shore (particularly the Keweenaw

Peninsula). Bird observatories at Thunder Cape (on the Sibley Peninsula) and Whitefish Point (50 km NW of Sault St. Marie) are well-located for monitoring migrating songbirds, raptors, owls and waterbirds. At Thunder Cape, the most commonly banded species include black-capped chickadee, dark-eyed junco, yellow-rumped warbler, Swainson's thrush and palm warbler. Good numbers of sharp-shinned hawks and northern saw-whet owls are also banded. Black-capped chickadee, Swainson's thrush, golden-crowned kinglet, yellow-rumped warbler, Nashville warbler, and Tennessee warbler are commonly sampled at Whitefish Point. Nine sites along the north shore of Lake Superior have been identified as potential IBA's (important bird area) by Birdlife International. Many of these sites are important migration staging or stopover areas (e.g. Thunder Cape, Whitefish Point).

6.1.12 Areas of Quality

The Binational Program's Habitat Committee has developed ecological criteria for identifying components of the Lake Superior system that warrant special attention. Areas of quality include significant ecosystems, communities and species habitat.

Addendum 6-D is an inventory of important habitat sites in the Lake Superior basin.

6.1.13 Stresses on the Ecosystem

6.1.13.1 Changes in Forest Composition

Not only has the total area of forests in the Lake Superior basin been reduced since historical times, the species composition is different. Pre-settlement forests on the U.S. side of the basin were predominately spruce-fir (41 percent) particularly in Minnesota, or northern hardwood (39 percent) in Wisconsin and Michigan (Figure 6-59). Fire-dependent forests of white, red, jack pine combined accounted for 14.8 percent and aspen-birch represented only 1.4 percent. In the U.S. portion of the basin, pioneer species such as aspen are now more abundant than before settlement (Frelich 1995). For example, in the protected Porcupine Mountains and Sylvania Wilderness northern hardwoods predominate as in historical times, and aspen-birch stands represent only about 1.4 percent of the forest. However in surrounding commercial forests, approximately 23 percent is aspen-birch dominated (Frelich 1995). Increased browsing of hemlock by deer has contributed recruitment failure and a gradual conversion of hemlock stands to northern hardwoods and spruce-fir where white-tailed deer numbers are well above historic levels (Frelich and Lorimer 1985).

Red and white pine have been much reduced in abundance on both sides of the border due to selective timber harvest near the turn of the century, blister rust, and fire suppression (see White Pine). In Canadian boreal forests, no comprehensive data are available describing the pre-settlement forests of the basin. However, it appears that balsam fir, balsam poplar, and aspen have increased due to fire suppression and extensive selective harvesting of the spruce, pine, and cedar component.

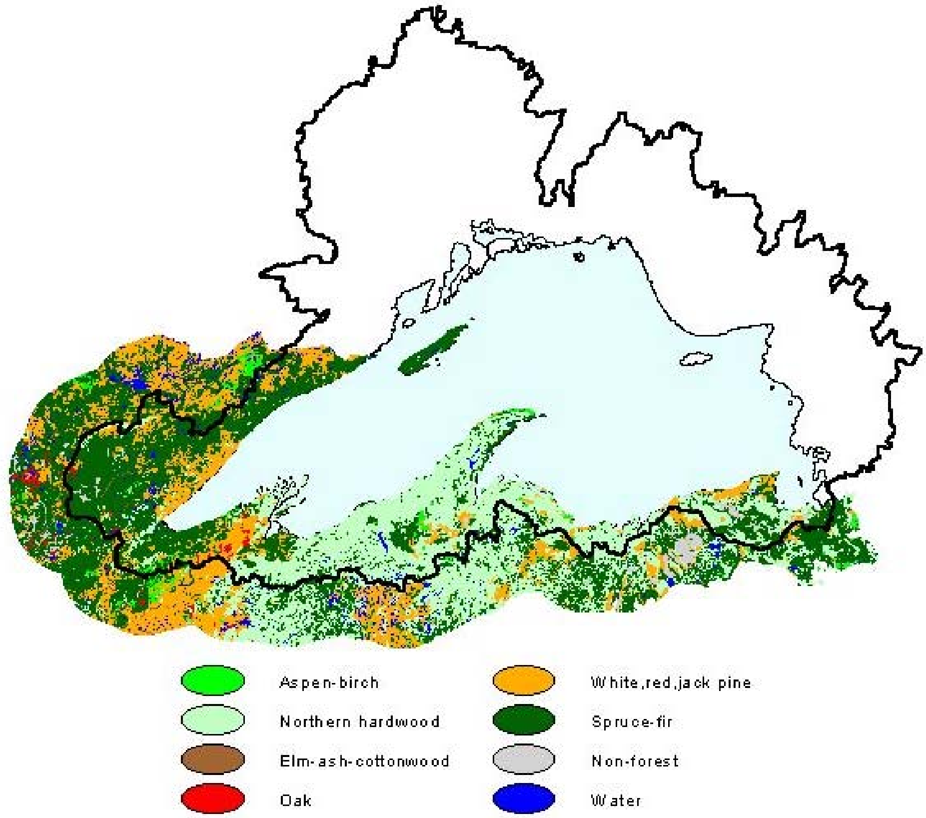


Figure 6-59. Historic forest cover in the U.S. portion of the Lake Superior Basin

The age structure of forests in the Lake Superior basin has also changed with respect to pre-settlement forests. In the predominately boreal forests of the Canadian portion of the Lake Superior basin, there are fewer very young forests than expected under natural conditions. Commercial forests for all of Ontario are dominated by 40- to 80-year age classes (Figure 6-60) (OMNR 1986), and this pattern is expected to hold true for those of the Lake Superior basin. Under natural fire regimes, a more or less negative exponential age class distribution is expected on a landscape scale, with most of the area in very young age classes i.e,. <20 years (Van Wagner 1978). The lengthening of the fire interval from approximately 65 years to over 500 years due to active fire suppression in this century is primarily responsible for this shift in age class distribution (Ward and Tithecott 1993). At the same time, there is less old growth red and white pine in fire-driven Great Lake St. Lawrence forests on both sides of the basin, primarily due to selective harvesting (see Old Growth/White Pine). In comparison, there is less old forest, and more young and mature northern hardwood, hemlock and oak forests within the Lake Superior basin than in pre-settlement times. This is as a direct result of the clearing of forests for timber, agriculture and development.

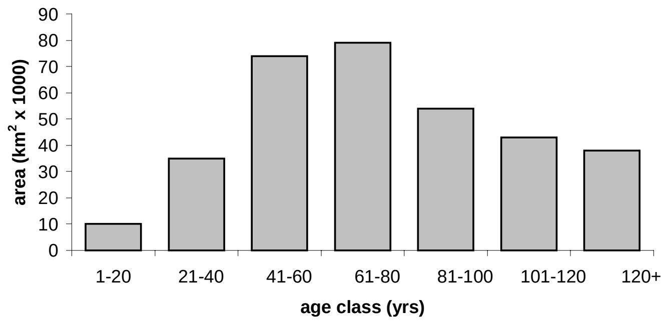


Figure 6-60. Age class structure of the Ontario commercial forest (OMNR 1986).

6.1.13.2 White Pine

White pine are of special significant in the Lake Superior basin due to concerns about logging in "old growth" stands, its commercial importance, biodiversity, decline, cultural significance (historical, aesthetics). The present white pine range in the Lake Superior basin includes all of the lake states and areas of predominately Great Lakes St. Lawrence forest along the border with Minnesota and north of Sault Ste Marie. Approximately 3,500,000 ha or 1.9 percent of the forest in northwestern Ontario has at least 10 percent white pine in the overstory (Simson 1993). Approximately 65 percent of the white pine occur as a 10 percent component in stands

In much of the basin, white pine is an uncommon component of the forest and found in small, widely distributed stands that are isolated from each other and vulnerable to loss (Simpson 1996). The vast majority of the white pine in northwestern Ontario is not found in pure stands but as mixed woods in association with black spruce, balsam fir, jack pine, trembling aspen, white birch and red pine (Perera and Baldwin 1993). Only 13 percent of all the white pine in northwestern Ontario are in stands defined as white pine by the Ontario white pine working group. In 65 percent of stands with white pine, the species accounts for only 10 percent of the basal area (Bowling and Niznowski 1996). Carlton and Arnup (1993) have suggested that red and white pine forests are generally restricted to four physiographic site groups:

1) Conifer-dominated stands on dry, infertile, very shallow soils over bedrock, with low white pine site index.
2) Conifer-dominated stands on dry to fresh, deep, sandy soils of glaciofluvial origin, with medium white pine site index.
3) Mixed conifer-hardwood stands on dry to moist shallow coarse loamy soils of morainal origin, often on slopes, with medium to high white pine site index.
4) Mixed conifer-hardwood stands on deep, coarse loamy, fine loamy or silty soils of morainal or lacustrine origin, usually with level topography, with high white pine site index.

Mature white pine forests have been replaced by spruce-fir forests due to selective harvesting of white pine in the early 20th century and fire suppression. White pine harvest reached a peak between 1890 and 1910. For example, white pine has decreased from 37.5 percent of the presettlement forests in BWCA to 10.2 percent currently, and from 29.5 percent to 5.9 percent in adjacent commercial forests (Heinselman 1973; Frelich 1995). The age class distribution of white pine in white pine working group stands in northwestern Ontario is skewed to the older age classes. For example, all 1177 ha (excluding barren and scattered) of white pine on the Thunder Bay Crown Unit were >80 years, with 3 percent greater than 121 years of age (Bowling and Niznowski 1996). The low abundance of younger age classes is a result of poor regeneration due to fire suppression. Replacement of old white pine as they die of old age, by fir, spruce, and shade tolerant hardwoods has occurred in northern Minnesota (Heinselman 1973) due to fire suppression activities. The lack of forest fires discourages successful white pine regeneration and is a major factor in its slow recovery in Ontario mixedwoods (Bowling and Niznowski 1996). In the absence of major disturbance, the pine component is expected to decline and be replaced by hardwoods and shade-tolerant conifers such as balsam fir and white spruce.

6.1.13.3 Forest Fragmentation

Forest fragmentation is a landscape-level process in which forested areas are subdivided into smaller, geometrically more complex, and increasingly isolated patches (Harris 1984). Forest fragmentation results from natural processes such as wildfire, wind, insects and climate effects, in combination with human land use activities e.g., urbanization and deforestation due to timber extraction and clearing for agriculture. Human activities may also affect patterns of natural disturbances, as in the case of fire suppression.

Forest fragmentation is one of the most prevalent landscape change occurring within the Lake superior basin. It is recognized as a major cause in declining biodiversity (Whitcome and others 1981). For example, habitat loss as a result of forest fragmentation was a factor in the extirpation species such bison, elk, cougar, wolverine and black bear from all or much of their range in the Lake Superior basin (Matthiae and Stearns 1981). The target for forest fragmentation identified in Ecosystem Principles and Objectives is:

> *No further increase in forest fragmentation in the Lake Superior basin as measured by several complementary indices of landscape composition and pattern. A decrease from the current level of fragmentation is desirable*

Landscape indices or metrics that are typically calculated to determine the degree of forest fragmentation include:

- **Class area** is the amount (percent or ha) of watershed comprised by the class, in this case closed-canopy forest. It is equivalent to a measure of habitat loss or grain.

- **Mean patch size** is the average size of patches (ha). Smaller habitat patches indicate and increase in forest fragmentation.

- **Total Forest Edge** is the total length of forest edge on the landscape. It may be a critical measurement of forest fragmentation since many of the adverse effects of fragmentation area related to edge effects (McGarigal and Marks 1993). Edge effects caused by the differences in wind and light intensity along the edge of forest patches affect vegetation and the juxtaposition of different habitat types are considered of great importance to wildlife species.

- **Mean core area** is the average size of disjunct core area patches in ha. Core areas are the interior area of a landscape patch defined by a core area buffer distance (width of the edge effects). Core buffer distances are species dependent, but 200 m is often considered the distance at which edge effects are attenuated. Core areas are particularly important for forest interior species such as hermit thrushes that are adversely affected by edge effects like increased predation and brood parasitism (Wilcove 1985). It differentiates between forest patches with similar overall area but different shapes since patches that are more circular in shape have a higher amount of core area than more linear or irregular-shaped patches.

- **Core Area Standard Deviation** is a measure of patch size variability that indicates whether only a patch size is evenly distributed, or rather there are a few very large and many small patches. This can be reported as a statistic and/or presented as a frequency distribution

- **Mean nearest-neighbour distance** is the average distance between forest patches. It can affect mea-population dynamics of spatially divided populations and plays an important role in the conservation of endangered species.

A spatial pattern analysis program Patch Analyst (Rempel and others 1999) that is based on FRAGSTATS (McGarigal and Marks 1993) was used to analyse forest distribution in the Lake Superior Basin. Landsat TM satellite coverage classified by land use was used to derive metrics separately for mature, closed canopy forest cover for conifer, mixedwood and hardwood forests. At this level of resolution (200 x 200 m pixel), it appears the forests of the Lake Superior basin are not very fragmented. A total of 10,687,872 ha or 85 percent of the land base of the Lake Superior basin (excluding Lake Nipigon and Lake Superior itself) is classed as either conifer, hardwood or a combination. The 2393 patches averaged 4466 ha in area (median 8 ha), indicating that a few large patches comprised the vast majority of the total area. Total edge was 111,273 km for an edge density of 5.29 m/ha. However, at this scale of resolution, fragmentation metrics do not account for the effect of roads, and the landscape appears less fragmented than it is when roads are considered.

Forests in the basin are often fragmented by roads, which create an edge environment and often pose a barrier to movement of smaller animal species. Roadless wilderness, i.e. forest that is at least 1 km from all roads, accounts for 3,444,635 ha or approximately 44 percent of the Canadian portion of the basin (excluding Lake Nipigon). Most of the patches of the 1960 roadless wilderness are less than 1000 ha, but the vast majority (80 percent) of the total area is comprised in several large patches >10,000 ha each. These tracts are located around Pukaskwa National Park, east of Lake Superior Provincial Park, in the Schreiber Highlands, and west of Lake Nipigon (Figure 6-62). Mean and median patch size is 1750 ha and 20 ha respectively, indicating a disproportionate amount of area in large patches. There are approximately 25,265 km of edge and an edge density 7.3 m/ha. Much of the forest has primarily been fragmented by recent clear cuts and tertiary roads associated with timber harvesting which encompass at least 1,229,416 ha (Figure 6-61). Much of the forest around the city of Thunder Bay that has historically been logged and/or is privately owned is not reflected in Figure 6-61.

No estimates are currently available for roadless wilderness on the American side, but the area (ha) and proportion of roadless wilderness are expected to be considerably less.

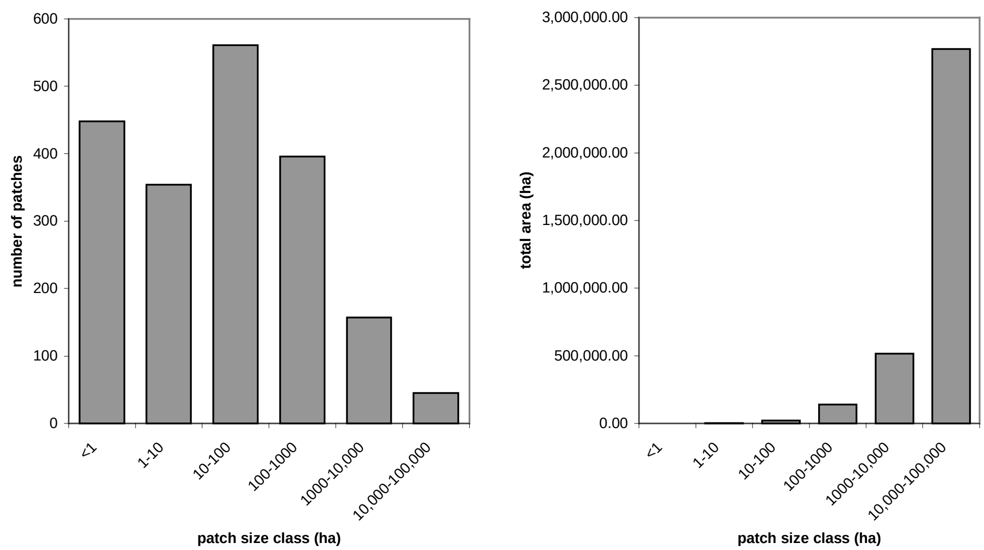


Figure 6-61. Number and area of roadless wilderness patches (>1 km from nearest road) in the Canadian portion of the Lake Superior basin

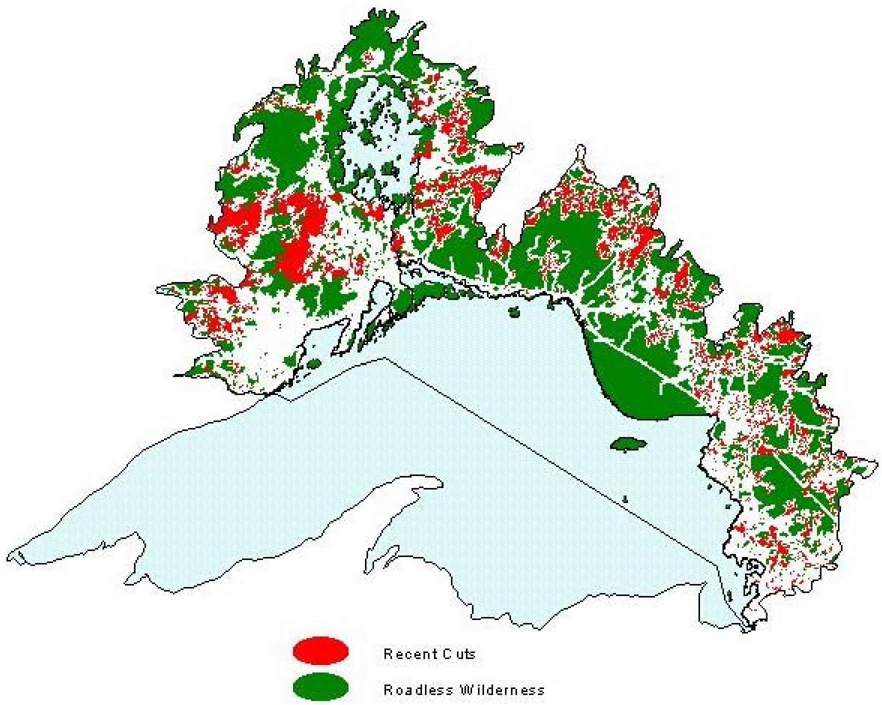


Figure 6-62. Roadless wilderness (>1 km from nearest road) and recent cuts in the Canadian portion of the Lake Superior basin

6.1.13.4 Pollution and Nutrient Loading

Pollution and nutrient loading have severely degraded some harbours, streams and wetlands. While less extensive than other Great Lakes, pollution has degraded habitat on Lake Superior.

Pollutants in Lake Superior originate from a variety of sources, including point sources, non-point sources and tributary discharge. Point sources are those originating at an identifiable point, such as industrial effluent, waste dumping, and spills (Table 6-30). Non-point sources are more diffuse and may originate from outside the Lake Superior Basin. Atmospheric deposition in the form of contaminated rain, snow or dust is a major sources of some pollutants. Others include agricultural and urban surface runoff and release of pollutants from contaminated sediments. Tributary discharge refers to pollutants entering the lake through tributary streams transported from elsewhere in the watershed, although ultimately these pollutants originated from point or non-point sources.

Table 6-30 Point sources of pollutants in the Lake Superior watershed (LSBP 1995)

	Water Sources	Air Sources	Dumps
Ontario	20	27	190
Michigan	36	14	na
Minnesota	72	216	40
Wisconsin	40	5	105
Total	168	262	145

Nutrient loading is increased input of plant nutrients, such as phosphorus. While these nutrients are not harmful at normal levels, excessive levels can have negative effects. Agricultural and urban runoff, sewage treatment plants and faulty septic systems are sources of nutrients.

Pollutants and nutrient loading can result in loss of habitat. In addition to toxic effects, water pollution can act as barrier to migratory fish. Point sources also have local effects on aquatic life through thermal pollution, biological oxygen demand, turbidity and bacterial contamination.

Nutrient loading can cause shifts in wetland vegetation. By encouraging species tolerant of high fertility (such as cattails), nutrient enrichment can cause reduced diversity of plant communities and loss of rare species and (Maynard and Wilcox 1997). Enhanced growth of algae and submergent plants, can cause oxygen depletion as the plants die and decompose.

Loss of fish and wildlife habitat due to pollution and nutrient enrichment is a local problem on Lake Superior. Habitat loss due to contamination has been identified at six of the seven Areas of Concern. However, these sites are typically at bays and estuaries, among the richest and most diverse habitats on the lake, and the consequences extend throughout the lake.

6.1.13.5 Sedimentation

Natural sedimentation processes of erosion, transport and deposition are essential for maintaining healthy coastal wetlands and sand dunes (Wilcox and Whillans 1999). Sediments can form barrier beaches and sand spits that protect wetlands. Some wetlands depend on sediment inputs to maintain vegetation. Active sand dunes are in a continuous state of flux as sand is deposited and eroded.

Man-made structures disrupt these processes. Breakwalls and revetments are structures placed parallel with the shoreline to enclose a harbour. Unintended side effects include scouring of sediments on the lakeside and increased erosion down wind as wave energy is transferred parallel with the wall. During high water levels, marshes inside the breakwall can be flooded out (Maynard and Wilcox 1997).

Groins are low walls constructed perpendicular to the shore. They are installed to protect beaches by intercepting longshore and beach drift. However, marshes and dunes that are eroded by storms may not be replenished if the supply of sediments is trapped by man-made structures (Maynard and Wilcox 1997). Similarly, dams on tributary rivers trap sediment that previously nourished estuarine wetlands. Wilcox and Whillans (1999) recommend improved designs for breakwalls and other erosion protection structures that incorporate the principles of sedimentation processes.

Excessive sedimentation from upland sources can also impair aquatic habitats. Increased erosion from agriculture, lake-level changes, logging, and urban land use can increase sediment deposition in streams, smothering fish spawning substrate and causing excessive turbidity.

The extent and magnitude of these impacts on Lake Superior habitats are unknown, but they are probably greater on the south shore than the north.

6.1.13.6 Exotic Species

Exotic species of plants and animals threaten habitat in a number of ways. Although there are hundreds of exotic species in the Basin, only a few are invasive enough to threaten natural habitats. This section discusses a few species with actual or potential impacts on habitat in the Lake Superior Basin, especially wetlands, aquatic and shoreline environments.

The risk of introduction of exotics to Lake Superior continues to be high. Increased ship traffic represents an enormous risk for the introduction of exotics. Trans-Atlantic ships are increasingly fast, increasing the likelihood that exotic organisms picked up in foreign ballast water will survive the passage. With improving water quality in Lake Superior harbors, recently arrived exotics are more likely to survive and reproduce. Currently, Canada and the United States only have voluntary guidelines in place regulating ballast water discharge. Effective legislation and compliance monitoring is required to regulate discharge of tanker ballast water. In addition, public education programs are essential to minimize further spread of introduced exotics. Most introduced species are impossible to eradicate, so prevention is the best measure.

Purple Loosestrife

Purple loosestrife is a well-known invasive plant of wetlands. Impacts of purple loosestrife can be severe. It has displaced up to 50 percent of the native plant biomass in some wetlands. Impacts on wildlife are not well understood, but some studies suggest serious declines in waterfowl and furbearers productivity in loosestrife infested wetlands (Thompson and others 1987). Competition with rare plant species is also a concern.

In the Lake Superior Basin, purple loosestrife is found around Thunder Bay, Duluth / Superior, Sault Ste. Marie and scattered other locations (Figure 6-63). It grows extensively along the Kaministiquia River and at number of other areas around Thunder Bay and north to Hurkett (David Ellingwood, LRCA, personal communication). Purple loosestrife is prevalent in the Sault Ste Marie area and the St. Mary’s River (Sue Greenwood, OMNR personal communication). In

Wisconsin, purple loosestrife is widespread, but still at low density in most areas, occurring in only about 5 percent of the total wetland area statewide (WI DNR 1999).

Control efforts have been introduced by At Thunder Bay, the Lakehead Region Conservation Authority has implemented control by digging plants and the introduction of beetles (*Galerucella* spp) that feed on loosestrife. The use of beetles has had mixed results (David Ellingwood personal communication). Minnesota has a statewide control program using herbicides and biological control (Skinner and others 1994). In Wisconsin, there are limited control programs in place by the Bad River Indian Reserve and the Apostle Islands Nationals Seashore (Gary Czypinski, personal communication).

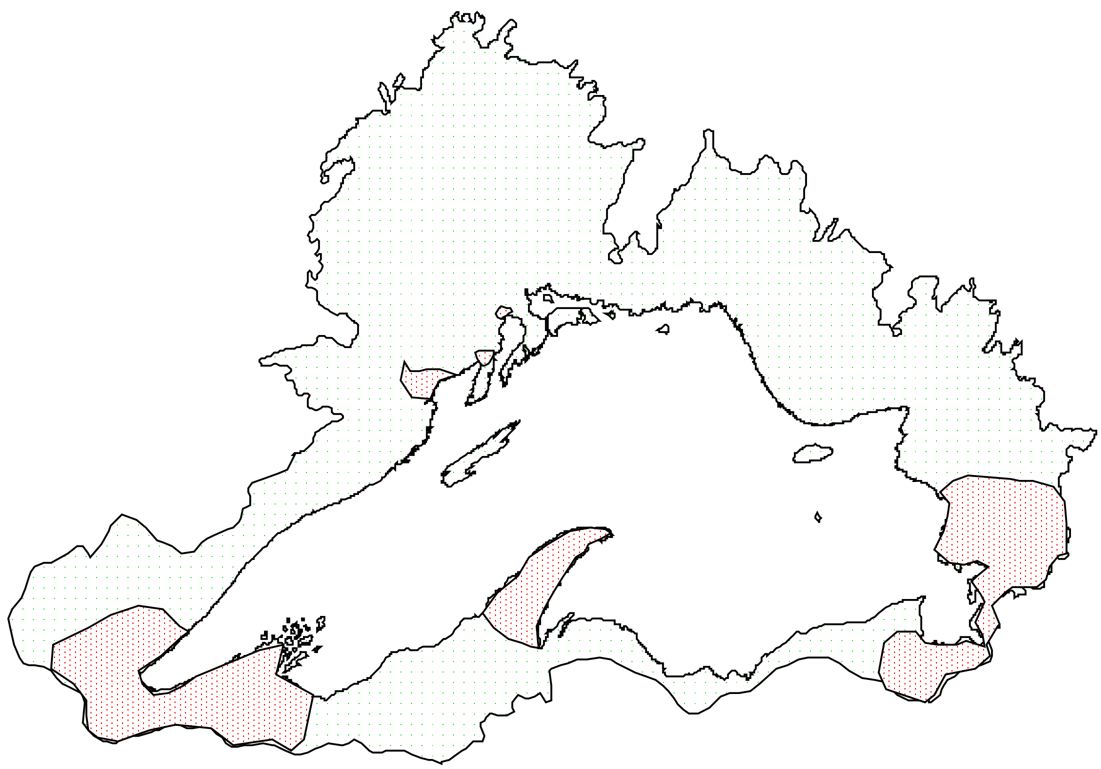


Figure 6-63. Approximate distribution of purple loosestrife in the Lake Superior basin Local occurences exist outside the shaded zones (Skinner and others 1994, Voss 1985, White and others 1993, WI DNR 1999)

Eurasian Water Milfoil

Eurasian water milfoil (*Myriophyllum spicatum*) is an extremely aggressive submergent plant native to Eurasia and Africa. It spread to inland lakes in the Wisconsin Basin by the 1980s, and was present in shallow bays of Lake Superior by 1993 (WI DNR 1999). In 1999 it was discovered in Lake Superior at Thunder Bay, but is suspected of being present for a number of years. It is not known elsewhere in the Ontario Basin (A.G. Harris personal observation).

Its preferred habitat is fertile, mineral sediments in eutrophic, nutrient-rich lakes. It is an opportunistic species that prefers highly disturbed lake beds, lakes receiving nitrogen and phosphorous-laden runoff (WI DNR 1999).

Dense stands of Eurasian water milfoil can alter nutrient cycling from the sediments to the water column and may lead to low oxygen levels and algae blooms. It displaces native plants. Some stands are dense enough to obstruct water intakes and inhibit swimming, boating, and fishing (WI DNR 1999).

Eurasian milfoil is unlikely to become widespread in Lake Superior due to its oligotrophic nature and fast water of most of its tributaries, but warmer, nutrient-rich bays and inland waters are vulnerable.

It reproduces from vegetative fragments and can be inadvertently transported between water bodies by boats. Control measures have focused on increasing public awareness of the necessity to remove weed fragments at boat landings. Mechanical and biological controls are being attempted in Wisconsin (WI DNR 1999)

Other Plants

Other potentially invasive exotic plants include reed canary grass (*Phalaris arundinacea*) (WI DNR 1999), giant reed (*Phragmites australis*), glossy buckthorm (*Rhamnus frangula*), queen of the meadow (*Filipendula ulmaria*), valarian (*Valeriana officinalis*) (Epstein and others 1997). These species are found in the Basin, but are not yet wide spread.

Gypsy Moth

Gypsy moth (*Lymantria dispar*) is one of North America's most devastating forest pests (USDA 1998). It was deliberately introduced to the US in the late 1800's and had spread to the eastern part of the Lake Superior Basin by the early 1990's (USDA 1998).

Widespread defoliation of forest stands occurs in peak years. Oaks are the preferred larval food, but other hardwood trees are also eaten. The impacts of defoliation on the forest ecosystem are not well understood, but probably cause reduce growth and survival of oaks, perhaps eventually leading to a shift in forest composition to less vulnerable species (USDA 1998).

Gypsy moths have been recorded in all of the Lake States and have infested the Upper Peninsula of Michigan. In Minnesota and Wisconsin, infestation is restricted to mainly urban areas but is now spreading to rural forests (Joe Meating personal communication.). There was a major outbreak in the Sault Ste. Marie, Ontario area in the late 1990s. Oaks are absent in most of the Ontario Basin, and extensive infestation is unlikely north and west of Sault Ste. Marie. All the states have monitoring programs. Control efforts have focused on slowing the spread by eradicating isolated colonies with pesticides and biological control methods (USDA 1998).

Zebra Mussels

Zebra mussels (*Dreissena polymorpha*) were introduced into the Great Lakes in the mid 1980's through ballast water discharge from transoceanic ships (Minnesota Sea Grant 1998).

Zebra mussels alter habitat by filtering particulate matter, including phytoplankton and some small forms of zooplankton from the water column. This reduces the food base for many small fish, increases water clarity and alters the nutrient flow of the lake. They also densely cover any hard substrate, including the shells of native mollusks.

They can become established over a wide range of depth, light intensity, and temperatures, but are rare in wave-washed zones, except for sheltered nooks and crevices.

Zebra mussels are confirmed at only a few sites on Lake Superior, including Duluth/Superior Harbor, Chequamegon Bay and most recently Whitefish Bay (Gary Czypinski personal communication). They are apparently not yet established on the Ontario side of Lake Superior, but have been observed attached to ships at the Thunder Bay Port and at Indian Harbour, Lake Superior Provincial Park (Jeff Black, personal communication, Sue Greenwood, personal communication).

The spread of zebra mussels in Lake Superior might be limited by low calcium availability and low summer water temperatures (below 12 degrees Celsius). As with other exotic aquatic species, controlling the spread by increasing public awareness is key.

Rusty Crayfish

Rusty crayfish (*Orconectes rusticus*) is native to the southern Great Lakes states, but has spread to lakes and streams in the Lake Superior Basin, probably by anglers using them as bait (Gunderson 1995).

Rusty crayfish alter habitat by reducing the abundance and diversity of aquatic plants, with consequent results on the fish, invertebrates and other species that depend on submergent vegetation for food and cover. They also feed on aquatic invertebrates and can displace native crayfish species (Gunderson 1995).

Rusty crayfish were discovered in 1985 in Pounsford Lake, Ontario and have since been found in the Neebing-McIntyre, Kaministiquia, Pigeon, and Little Pine rivers. They have invaded Pigeon Bay on Lake Superior, and are probably now in Black Bay (Momot 1995, W.Momot, personal communication). They are present in the Duluth/ Superior Harbor and other inland sites in Michigan and Wisconsin (Gary Czypinski personal communication).

Control efforts have included angler education to reducing the spread of crayfish to uninfested lakes and streams.

6.1.13.7 Recreational Use

The waters and shoreline of Lake Superior have witnesses a significant growth in the volume and range of water and land based recreational activities. There is however a paucity of empirical data that quantities the impacts of leisure and recreational pursuits on water quality and shoreline habitat. This assessment of habitat stress related to recreational activities is drawn from anecdotal evidence from park and resource managers and members of the academic communities within the Lake Superior basin.

Commercial and private shoreline development, specifically for holiday and leisure retreats has significantly changed the complexion and composition of natural habitats along extended sections of the Lake Superior shoreline. Developments, together with access roads and associated leisure facilities are the most visible consequences of leisure and recreational use of the lake.

The development and/or expansion of marina facilities (Redrock, Nipigon and Michipocoten Harbour in Ontario; Silver Bay and others on the Minnesota shore in various stages of advanced planning) reflect increases or anticipated increases in motor and sail boat traffic. Marina facilities inevitably concentrate boating activity and may amplify the impacts of fuel spillage, jetsam and unsanitary discharge of solid wastes. Conversely, if used as intended, marina facilities could help mitigate some of the impacts of increased boat traffic on the lake.

Sea kayaking is one of the fastest growing recreational activity in Apostle Islands National Lakeshore, Pukaskwa National Park and along the Rossport/ Nipigon island archipelago. Four sea kayak symposiums are conducted annually on Lake Superior. Kayakers have the ability and a preference to visit and camp in secluded bays and inlets. Pictured Rocks National Lakeshore as well as other high use kayak areas have expressed a concern regarding the concentration of debris and the unsanitary disposal of human waste in backcountry campgrounds. Monitoring plots have been located within the Pictured Rocks area however no long-term data is yet available.

Research regarding the effects of air emissions and gas and oil leaching from two cycle engines as found in snowmobiles and personal water craft has been conduced in some U.S national parks (Yellowstone) however no data was located for the Lake Superior basin. Both sledding and personal watercraft are popular recreational activities on or near Lake Superior. Aside from emissions that may impact air and water quality, the excessive noise of these activities and the pattern of repetitive use of trails or near shore waters may disrupt wildlife (terrestrial and aquatic) use of otherwise suitable habitats.

Off road 4X4 trucks and all-terrain vehicles have invaded and is some instances significantly impacted shoreline habitats. Blow outs and denuded sandscapes in the Pic River dune complex and to a lesser extent in the Michipocten Bay area (ON) are the scars of random and repetitive use by vehicular traffic. Similar impacts have been reported in areas within and adjacent to the Picture Rocks National Shoreline (MI). 'Off roading' disrupts and dissects inland and shoreline habitats, or prompt debris accumulation and careless and disruptive use of shoreline areas for recreational purposes.

The return of commercial cruise ships with national and international guests is a recent phenomenon on Lake Superior. For example, The MS Columbus, carrying about 350 visitors will make 4 cruses on Lake Superior in the summer of 2000. The docking schedule for the Columbus is limited to major ports; however the ship does carry small watercraft that would allow guests to disembark and explore remote and secluded shorelines. This eventuality could see repetitive, large group use of off shore islands or otherwise secluded bays and coves.

Evaluated individually, recreational activities would appear to have an overall marginal impact or, at worst a measurable localized impacts on the near shore and shoreline habitats of Lake Superior. It is however the cumulative effects of the major recreational activities and the multiplicity of associated services and facilities that supports the major recreational activities that may erode or fracture the integrity of natural patterns and processes. For example, the activity of deer feeding common to many property owners along the northern Minnesota shoreline will inevitably effect some changes in white tailed deer and possibly moose distribution and concentrations. The subtleties and extended time frame of these changes make it impossible to link a recreational activity that is perceived to be beneficial or benign to a change or stress in the natural habitat.

6.1.13.8 Shoreline Development

In comparison to other Great Lakes, the Lake Superior shoreline is relatively undeveloped. On the U.S. side, substantial portions of the eastern shoreline and some sizable tracts in the western basin are under federal or state ownership. About 90 percent of the Ontario shoreline is owned by the provincial government. A significant portion of the Lake Superior shoreline is protected in parks and protected areas. Despite the relatively low human population and a large degree of protection, the success in protecting or restoring shoreline habitats varies tremendously among the jurisdictions.

In recent years the impact of shoreline development on Lake Superior habitat has been a primary focus in many management forums. At both the 1996 and 1998 State of Lake Ecosystem Conferences (SOLEC), papers were presented that described shoreline processes and explored stresses on these habitats. Although there are few standards to mark the limit or extent for shoreline considerations, they generally include lands extending up to a kilometer from Lake Superior.

Shoreline habitats represent the fragile interface between land and the lake and are particularly sensitive to human stresses. Stresses associated with shoreline development include disruption of natural erosions and sedimentation processes by groins, filling wetlands, increased human disturbance of wildlife, and increased pollution from wastewater, stormwater runoff and septic fields (Thorp and others 1997).

In some areas, shoreline development on Lake Superior has been substantial and is expected to continue to increase. Uncontrolled development takes many forms, including industrial, agricultural, commercial, and residential, and can lead to significant cumulative impacts for natural shoreline habitats. Land use along Lake Superior is generally connected to the Basin's economy, the movement towards industrial restructuring, and the proximity of urban centres which facilitate sprawl. Although proximity to water for transportation and industrial purposes were the early factors in shoreline development on Lake Superior, many new trends appear to be emerging.

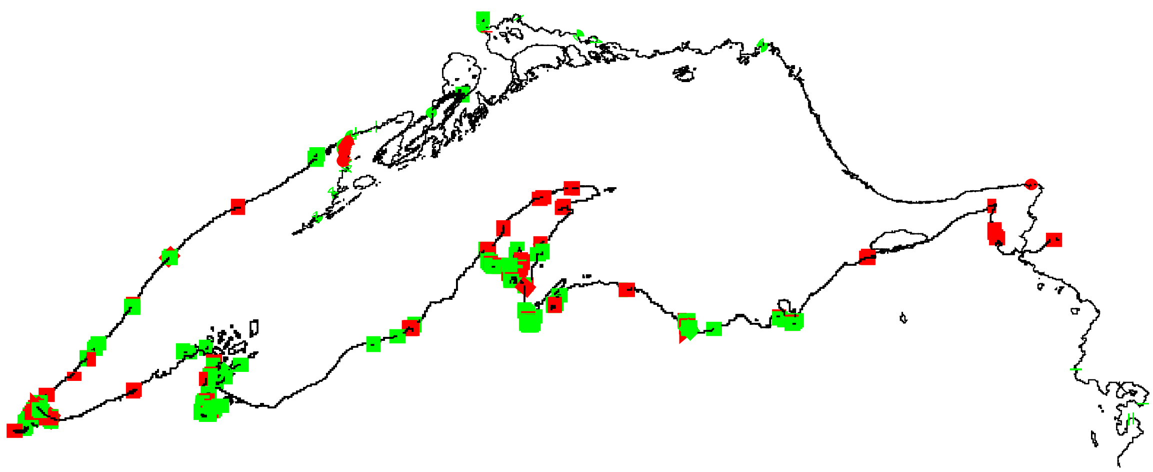


Figure 6-64. Man-made shorelines: red is retaining walls, harbour structure, and breakwater; green is rip-rap (Compiled from U.S. EPA 1994 and Environment Canada 1993).

In recent years, development of seasonal second homes and cottages has increased significantly. Lake Superior is increasingly viewed has a desirable location for residential use in both rural and urban settings. Large parcels of privately owned land are now regularly subdivided for potential residential development as the market demand increases for waterfront homes. For example, over 50 percent of the homes in Keweenaw County on Michigan's Upper Peninsula are now classified as second homes. As the baby boom generation approaches retirement age, there appears to be a trend towards more permanent shoreline residences. The increase in residential and cottage development and the associated infrastructure, can dramatically impact sensitive shoreline habitats. These impacts include the: construction of access roads that fragment wildlife travel corridors; removal of native shoreline vegetation; construction of harbours and marinas in sensitive estuaries; lake filling; and erosion control structures or breakwalls that impair natural sediment transport processes. In some cases residential developments permitted in areas of shallow soil or rocky headlands, can also lead to temporary or long-term contamination of land and water resources through faulty septic systems.

Approximately 5 percent of the Lake Superior shoreline consists of artificial, made-made structures (Figure 6-64) (Much of the artificial shorelines is concentrated near cities at the mouths of the larger rivers (Nipigon, Kaministiquia, St. Louis), and in many cases is probably replacing wetland habitat. Other areas with significant artificial shoreline are the Bayfield Peninsula (presumably associated with erodable red clays) and the Keweenaw Peninsula.

Among the areas with the greatest growth in human population are the Keweenaw Peninsula, Bayfield Peninsula, northeastern Minnesota and eastern Michigan. The Keweenaw Peninsula has seen unprecedented growth in the past 20 years, mainly as recreational homes. A coalition of residents who felt frustrated by the increasing level of shoreline development they witnessed along the peninsula. They had noticed that some of the most scenic lakeshores, home to unique ecological communities and rare plants, were the same areas frequently being subdivided or subject to other development proposals. The placement of raised sand septic fields in shallow soiled rocky headlands and the filling of sensitive wetland habitats were specific concerns.

Population growth in the eastern Michigan counties may threaten the basin’s many endangered species and communities associated with the sand dunes.

Shoreline Regulation

There is no comprehensive data on the extent, distribution, or trends in shoreline development on Lake Superior. Information of this type would need to be obtained from individual municipal offices and through other land use control sources.

From a regulatory perspective the issue of land-use planning along Lake Superior's shoreline is complex. The responsibility for land-use decisions is fragmented among many government regulatory agencies. Often the decision-making authority rests with small local municipalities or county governments that are ill-equipped to handle thorough environmental assessments. In many cases, these local governments encourage shoreline development as a mechanism for increasing their tax base.

Overall there does not appear to be a comprehensive mechanism in place to determine the annual shoreline development approvals. Nor does there appear to be a process for the implementation of uniform development standards (i.e. set back requirements) for new shoreline developments in the Lake Superior Basin (Thorp and others 1997). Although some regions may be making individual efforts to compile statistics on the subdivision of shoreline properties, this appears to be one area where significant data gaps exist. There needs to be a better understanding of the cumulative consequences of local land-use decisions in relation to shoreline habitat impacts.

Shoreline Development

While there are many initiatives underway dealing with water quality on Lake Superior we are aware of no concerted effort to look at current and potential housing development trends on the Lake Superior shores... Memo from Lake Superior Cooperative to Environment Canada & U.S. EPA 1997

Larger populations and easier access to the south shores of Lake Superior and the surrounding states are probably driving an unprecedented desire to purchase waterfront property and expand recreational opportunities. There seems to be a "ripple effect" with development pressure moving out from large metropolitan areas to the inland lakes and rivers of the Great Lakes states to the shores of Lake Superior. This appetite for "being on the water" may be moving a little faster on the south shores of Lake Superior than on Canada's Superior shores.

Demand has driven land use, riparian development and recreational use conflicts to the top of "issues of concern" piles across the Great Lakes region. In northeastern Wisconsin, inland lake properties were commonly selling at $200 (U.S.) per front foot in 1990. Nine years later some waterfront properties are selling for as much as $6000 per front foot. Choice property is gone… smaller lakes with wetland shores, steep slopes, erodable soils and prime wildlife habitat are all that is left. Rising prices drive up property taxes and encourage the splitting of larger parcels. Some predict that if current rates of development continue wild lakes and shoreline in Wisconsin will disappear in the next ten to twenty years.

Lake Superior shores in the U.S. are receiving the same type of pressure. In Michigan, Wisconsin and Minnesota small communities on Lake Superior are experiencing an influx of people building recreational homes or buying condos. Most of Superior's shores are rocky and exposed to heavy wave action; only about 17 percent are protected well enough to provide habitat for wildlife (estuaries, shore wetlands, river mouths, and protected bays). The majority of these protected areas are where cities and marinas are located. Prime building spots are rare. Rocky bluffs sport rows of huge steel and wood stair complexes giving recreational homeowners the ability to reach the water. They construct piers of stone, rock and concrete to protect their boats from the lake. Homeowners tend to remove trees, shrubs and vegetation to gain a "better view of the lake." The result… loss of habitat and, from the lake, a view of homes.

Highways also hug many miles of Superior's shore, and often new homes are squeezed into the ribbon of land between the road and shore. Homes allowed too close to the shore areas of Lake Superior are exposed to flooding during high water or storm events, causing erosion, property damage and shore edge destruction.

The land use planning practices of the Provincial Government have kept much of the north shore of Lake Superior "intact." These wise policies will leave an irreplaceable and formidable legacy for the people of Canada and those who visit.

Communities struggle with the issues of economy vs. environment but new solutions are being found. Responding to requests from the local officials concerned with the explosive growth, Wisconsin has spent $2 million in the past three years to help local governments develop a lake classification system. The idea is to guide development in sensitive lakeshore areas on inland lakes. Twenty-seven northern counties are developing stronger land use strategies and rules on their shorelands..
Protection of the world's lake ecosystems is a global responsibility and Lake Superior is a lake with linkages that are truly global in scope. As long as there are people here, there will be changes, but we can work to make development less stressful on the lake environment. There are many areas that need more work. They include:

- Inventorying current educational programs and materials regarding shoreland development.
- Reviewing current zoning and land use ordinances and their enforcement.
- Continuing research on the impacts of shoreline development.
- Working with and bringing together local communities, government units and concerned individuals to develop long- term solutions and visions for the Lake Superior shorelands.
- Discussing the possibility of developing a Lake Superior-wide set of building standards.

Lake Superior is distinctive in another way… it is teaching us that the consequences of our activities anywhere in this basin can affect all who enjoy the benefits of the lake. As more new development appears, centuries old aquatic habitats, the creatures that live there, aesthetics, and the wild character that draw people to Lake Superior will continue to disappear.

We who live here have an opportunity to think of ourselves as a community instead of a state, province or nation. We can find ways to work together as governments, industries and individuals to integrate environmental and economic issues. We can adopt the type of policies that follow natural processes rather than resist them. If we are willing to persist on these issues and recognize our shortfalls, then the future of Lake Superior looks bright.

One positive trend has been the reclamation of former industrial lands in some urban communities. Recent shifts in markets, has in some waterfront cities, reduced the industrial demand for shoreline sites. As a result many urban centres have recently focused their attention on developing strategic waterfront plans that encourage the acquisition of former industrial lands in an effort to improve public waterfront access or to encourage the restoration of green space along the shore. It is expected that this trend may continue in many centers within the Lake Superior basin. This renewed public appreciation of the aesthetic and recreational attractions of the Lake Superiors shoreline has unfortunately also served to increase development pressures in many previously remote regions of the lake.

6.1.13.9 Dams and Water Diversion

Hydroelectric Generation

There are major 15 hydroelectric generating stations in the Ontario Lake Superior drainage basin on the Aguasabon, Kaministiquia, Michipicoten, Montreal, Nipigon and Wolf rivers (Cheng 1987). Numerous smaller projects are also present.

Ontario Hydro identified ten undeveloped major sites (>10 megawatt potential) within the Basin, including the Pic, University and White rivers (Cheng 1987). An additional 28 sites with 2.0 - 10.0 avg. megawat potential have been identified on the Agawa, Aguasabon, Black Sturgeon, Magpie, University, Pukaskwa, Pic, Steel, Namewaminikan, Kopka, Gull, Kaministiquia, Pigeon, and Ogoki rivers (Cheng 1987).

In the U.S. basin, the number of hydroelectric dams is limited by the small watersheds. The St. Louis River watershed has five hydroelectric dams, but the 1930 Shipstead-Nolan Act of Congress prohibits construction of dams or other water-fluctuation structures in St. Louis, Lake and Cook counties Minnesota (MPCA 1997). Wisconsin has five active hydroelectric dams in the Basin. There is potential for future developments at a number of sites (Turville-Heitz 1999).

A landslide on the Nipigon River in 1990 was partly attributed to water level fluctuations caused by a hydroelectric dam. Heavy siltation caused by the slide damaged fish habitat and forced the Town of Nipigon to relocate its water intake (Atria Engineering Hydraulics Inc. 1993). Rapid draw down for hydroelectric generation contributed to the initial slide on the riverbank, which was followed by failure of the land behind the bank (Atria Engineering Hydraulics 1993). Other factors were the naturally susceptible soils, high soil moisture due to sudden thaw, natural erosion by river water, removal of tree cover by logging and disruption of drainage patterns by a pipeline right of way. Smaller slides are common on the river. A sudden drawdown on the Nipigon River in 1998 caused spawning salmon to be stranded (Rosemary Hartley, Nipigon District OMNR, personal communication).

Other potential impacts of hydroelectric developments on the Lake Superior ecosystem include elevated levels of methylmercury associated with reservoirs, altered water regimes resulting in disrupted spawning cycles (e.g. brook trout in the Nipigon River), and barriers to fish migration.

The number of potential hydroelectric sites that will eventually be developed depends on supply-and-demand for electricity and initiatives by local businesses and communities. Environmental assessments are required for new hydroelectric projects. However, it is difficult to determine the cumulative impacts on the Lake Superior ecosystem if numerous small projects are established.

Water Diversion Projects

Waters from the Albany River Basin, which formerly flowed into Hudson Bay, have been diverted from the Ogoki and Kenogami rivers and now flow into Lake Superior. The purpose of the diversions was to increase flows at hydroelectric dams and improve log drives.

The Long Lac diversion was established in 1939. It consists of a concrete overflow dam on the Kenogami River at Long Lac. The diverted water passes through a channel built across the watershed divide and into the Aguasabon River, which drains into Lake Superior. A concrete dam at the end of the channel regulates flows. Since 1940, an average of 1,400 cubic feet per second (cfs) has been diverted to Lake Superior (IJC 1976). Electricity is generated at a power plant near the mouth of the Aguasabon River in Terrace Bay. This diversion was also used for the transport of pulpwood logs southward.

The Ogoki diversion was established in 1943. It redirects water from the Ogoki River into Lake Nipigon, which flows into Lake Superior via the Nipigon river system. The Waboose Dam on the Ogoki raises water levels so that most of the flow is redirected across the watershed divide, and then through a number of small lakes into the Jackfish River and into Lake Nipigon. The Summit Dam controls the amount of diverted water. The diversion discharges an average of 4000 cfs (IJC 1976). Since 1943 the diversion has had closures and reduced flows on at least 25 occasions for a variety of reasons. A generating station at Pine Portage at the top of the Nipigon River controls the outflow. Pine Portage generating station is the first of three hydroelectric plants on the Nipigon River. A minimum flow of 8000 cfs is required to ensure appropriate water levels for the town of Nipigon's water supply system. Flows in excess of 20,000 cfs would endanger the railway and highway bridges at Nipigon.

In 1951-53, the volume diverted from the Ogoki River was reduced during a period of high water. Diversion of water was stopped for a numbers of months in each of these high water years. Ontario Hydro reduced water diversions again during 1972-74. During this period the outflow through the Nipigon River was reduced to natural levels and diversion waters were stored in Lake Nipigon. Once Lake Nipigon reached peak levels water diversion was completely halted and Ogoki flows were temporarily diverted north again.

The Long Lac and Ogoki diversions have had significant local environmental effects resulting from the initial construction and operation of the diversion structures, channels and reservoirs. Greatly altered flow regimes and the accumulation of bark and other woody debris from log drives represent a continuing stress on the local environment and negatively impact upon fish spawning habitat. Lower reaches of the Little Jackfish River on the Ogoki Diversion experience severe erosion of unconsolidated glaciolacustrine sediments which has resulted in increased siltation and turbidity stresses of the Obamika Bay on Lake Nipigon. This has contributed to the decline of the walleye fishery, and may also be responsible for the increase in sauger compared to walleye (Bridger and Day 1978).

The Long Lac and Ogoki diversions have also had significant hydrological effects on the Great Lakes. The mean water level of Lake Superior has increased by 6.4 cm, Lakes Migichan-Huron by 11.3 cm, Lake Erie by 7.6 cm and Lake Ontario by 6.7 cm. The changes in water level attributed to the diversions result in an estimated annual loss of $4.8 million due to erosion and flooding. However, direct benefits to the pulp and paper industry (located on the Aguasabon River), navigation (higher water levels permit greater loads), and power generation are estimated to exceed the calculated losses by $57 million annually. The effects of water level increase on recreational boating and beach use have not been quantified for Lake Superior, but generally raising water levels benefits boating and harms beaches. No basin-wide negative environmental effects have been documented for these two diversions (IJC 1985). No introductions of aquatic species from the Arctic watershed have been reported.

6.1.13.10 Lake Level Management

For over 150 years, the outflow of Lake Superior at Sault Ste. Marie has been modified to improve navigation and hydroelectric generation (Environment Canada 1993). Power canals and navigation channels increased the amount of water that could be discharged. The increased capacity required the construction of control works to compensate for the increased outflow capacity from Lake Superior.

The Lake Superior Board of Control was established to supervise the operation of all control works, canals, headgates, and bypasses and to formulate rules for them. The Board's goal is to regulate the level of Lake Superior in such a matter as not to interfere with navigation, protect the sport fishery in the rapids of the St. Mary's River and ensure adequate flow for hydroelectric generation. Flow regulations also help prevent ice jams in the St. Mary's River.

Regulation of Lake Superior also depends on water levels in the lower Great Lakes. In its 1976 report to U.S. and Canadian Governments the IJC advised that regulating the levels of Lake Superior could provide benefits throughout the Great Lake system if the regulation took the levels of lake Michigan-Huron into account. When Lake Superior's levels are much higher than average and Lakes Michigan- Huron are only slightly above average, the outflow from Lake Superior is increased to ease high water levels. If Lake Superior is very much below average and Lakes Michigan-Huron are only slightly below average, the outflow from Lake Superior is reduced in order to raise its level. Similarly, regulating outflow from Lake Superior can compensate for extreme high or low water levels on Lakes Michigan and Huron.

One of the main objectives of the IJC's 1914 order was to maintain Lake Superior levels within a more narrow range than was recorded through past monitoring history. However, this objective soon proved impossible when record high and low water levels occurred in later years. In the 1950s, the maximum water level as prescribed in the 1914 Order was exceeded. During the mid-1950s to the 1960s, water levels were also frequently below the minimum level.

In the mid-1960s, when water levels were extremely low on Lakes Michigan-Huron, Lake Superior was used to help alleviate the situation on these lakes. Permission was granted to discharge outflows greater than the regulation plan. Then in the early 1970s, Lake Superior flows were reduced as part of an emergency action since water levels were critically high in the lower Great Lakes.

In the spring of 1985, Lake Superior's outflows were again reduced because of high water levels in the lower Great Lakes. However after four months of flow reductions it became necessary to reverse procedure and increase outflows since large amounts of precipitation on the Superior basin had caused the Lake to climb to a record high level. Continued rains saw Lake Superior levels exceed the level of 603.2 feet (186.86 meters) for a period of two months despite allowing the largest outflow on record.

The presence of Lake Superior compensating facilities does not mean that full control of Lake Superior's water level is attainable or desirable. Lake Superior levels are greatly effected by natural conditions that cannot be controlled such as evaporation, run-off, and over-lake precipitation. Since these factors cannot be accurately predicted, levels on Lake Superior remain largely a product of natural occurrences (IJC 1993, Tushingham 1992).

The effects of water level regulation on the lake ecosystem are not well understood. The reduced range of high and low water levels influences wetland and shoreline plant communities, but site-specific studies are needed to evaluate the effects of fluctuating water levels on the Great Lakes fishery. Wilcox and Whillans (1999) call for the restoration of natural lake level fluctuations on Lake Superior to restore wetland hydrological processes.

6.1.13.11 Dredging

In Lake Superior, dredging has been taking place since the early 1900s. Dredging involves removal of lake bottom sediments to maintain shipping and recreational boating channels. In the period 1937 - 72, 68.7 million m^3 were dredged from Lake Superior (Edsall and Charlton 1997).

Dredging can have harmful impacts on wetlands. In addition to loss of wetland area, dredging in shallow waters near wetlands can create new channels, altering water movements and changing nutrient regimes and plant communities (Maynard and Wilcox 1997). Dredging can also cause lower water tables and increased sediment loading in the rest of the marsh. Deepening the water adjacent to the marsh can prevent the natural migration of the marsh boundary during low water years.

Disposal of dredged material can also alter habitats. Dredge spoils are sometimes deposited in shorelines, filling wetlands or burying other shoreline communities (Thorp and others 1997). Depositing dredge spoils in nearshore habitats can bury spawning areas, but carefully planned open water disposal can have only temporary or minor impacts if spawning areas and other significant benthic habitat is avoided (Edsall and Charlton 1997). Most dredge spoils are now deposited in confined disposal facilities due to concerns about contaminants.

Dredging operations on Lake Superior regularly take place at the Thunder Bay harbour and the St. Louis River estuary at Duluth / Superior, with smaller operations at recreational marinas.

6.1.14 Information Gaps / Data Needs

While many studies have been completed at local scales, compiling information at the scale of the Lake Superior watershed is often hampered by incomplete information. Additionally, while comprehensive survey or inventory data is typically available in the more southerly portions of the states and province, similar information is often lacking for areas within the Lake Superior watershed. Filling these information gaps and compiling the data at the scale of the watershed are important to determine larger scale trends in the quality and quantity of habitat. Critical information needs and data gaps include but are not limited to:

- Complete stream classification and inventory
- Database of dams, loss of accessible stream length due to man-made structures
- Maintain a database of inland lakes
- Mapping rare community types
- Quantify shoreline development (no. houses/km for various sections, etc.)
- Lack of data on historical vegetation cover in Ontario

6.2 STRATEGIES, ACTIONS AND PROJECTS TO PROTECT AND RESTORE HABITAT

This section of the LaMP for Habitat recognizes “Strategies”, “Actions,” and “Projects” that will help identify, protect or restore habitat features and the ecological processes that sustain them. These draft strategies, actions and projects are presented for public comment and to develop a broader consensus of priorities among resource managers around the watershed. The numbered items are "Strategies" that target specific categories of activity that are recognized as essential to achieving the goals of identification, protection or restoration of habitat. Numbers do not imply priority rankings in any way. They merely provide a tool for referencing individual Strategies. In some cases, Strategies have more specific necessary "Actions" described that delineate components of the broader strategy. Actions that target individual jurisdictions or agencies indicate where the LSBP has identified information gaps that need to be filled or where there are regional differences in habitat needs.

Included in this chapter are also projects that have been developed by one or more of the LSBP partner agencies. These projects are underlined below and the lead agency working to implement the project is identified in parentheses. Where an agency is identified in association with a project, a level of commitment is indicated. The term "commitment" indicates that funding has been secured for the project and that it has either just begun or will begin in the next year. "Exploratory" indicates that the agency has proposed the project and is in the process of securing funding or other key support before beginning. "Future possibility" refers to projects that agencies feel are important, but which have not yet been formally proposed and additional work needs to be done before a project proposal is developed.

Partner agencies have committed to achieving the goals of habitat protection and restoration identified below. In addition, agencies have committed to the specific actions and projects in this LaMP document as identified in the sections that follow based on local or regional priorities and needs, organizational mission, and available funding or staff expertise. This list of strategies is not intended to commit agencies to complete each of the specific actions listed below. Instead it represents a long term planning approach to identifying management needs. Committed projects may, in some cases, be completed in one or two years. Others will be completed over several years. Strategies may have either fixed endpoints or, more often, represent priorities for work that needs to be initiated and continued over many years or decades. The scale of the Lake Superior basin and its importance as habitat for plants, animals and human communities necessitates long term commitments in management and coordination.

The goals that the habitat committee has established for habitat in the basin are the following:

1. To protect and maintain existing high-quality habitat sites in the Lake Superior basin and the ecosystem processes that sustain them.
2. To restore degraded plant and animal habitat in the Lake Superior basin.

Several principles guide the committee's work toward these goals. They are:

- The ecological well being of Lake Superior is determined in large part by the condition of its tributary lakes and rivers. Land use planning and regulation in the Lake Superior ecosystem should eliminate or avoid destructive land-water linkages (e.g. erosion of agricultural land, urban storm water, point and non-point sources of persistent contaminants), and foster healthy land-water linkages (e.g. continuous stream side vegetation buffers, on-site treatment of runoff).

- The long-term consequences of incremental or cumulative landscape change, habitat destruction, and habitat fragmentation should be anticipated and avoided in the Lake Superior basin through research and planning at appropriate spatial and temporal scales.

- The crucial importance of nearshore, shoreline and wetland aquatic habitats in Lake Superior should be addressed through efforts to identify, protect and restore key sites for reproduction and rearing of fish, water birds, mammals, and other wildlife and plants.

- It is vital to coordinate and support restoration/rehabilitation and protection efforts for priority sites. The committee would communicate with agencies and groups involved in habitat protection and restoration/rehabilitation around the basin to provide information about and encourage consistency with the habitat objectives of the Lake Superior Binational Program.

- Through outreach and education, promote partnerships in maintenance and restoration/rehabilitation activities in the basin, including strong participation from non-governmental organizations, stakeholders and other public groups.

Abbreviations found in this chapter are as follows:

Bad River Band of Lake Superior Chippewa	BR
Bay Mills Indian Community	BMIC
Chippewa-Ottawa Treaty Fisheries Management Authority	COTFMA
Fond du Lac Band of Lake Superior Chippewa	FdL
Grand Portage Band of Lake Superior Chippewa	GP
Great Lakes Indian Fish and Wildlife Commission	GLIFWC
Keweenaw Bay Indian Community	KBIC
Natural Resource Conservation Service of the U.S. Geological Survey	NRCS
Ontario Ministry of Natural Resources	OMNR
Red Cliff Band of Lake Superior Chippewa	RC
State Departments of Natural Resources	State’s initials (MI, WI or MN) and DNR
U.S. Environmental Protection Agency	EPA
U.S. Fish and Wildlife Service	FWS
U.S. Forest Service	USFS followed by the name of the National Forest proposing the project
1854 Authority	1854 Auth.

A project proposed by a Remedial Action Plan working group is signified by the name of the Plan, followed by “RAP.”

Strategies, Actions and <u>Specific Projects</u>

1. Complete comprehensive, systematic Natural Heritage Inventory/biological surveys in the watershed to identify remaining high-quality natural communities and locations of rare plants and animals.

- <u>Survey two sites on the Fond du Lac reservation.</u> (FdL - commitment)
- <u>Suzie Islands survey.</u> (GP - commitment)
- <u>Biological survey of the North Shore highlands subsection.</u> (MN DNR - commitment)

2. Complete comprehensive substrate mapping for nearshore waters, harbors, bays and estuaries of Lake Superior to identify important fish habitat.

- <u>Classify physical habitat in nearshore waters of Lake Superior in Michigan.</u> (MI DNR - exploratory)
- <u>Lake trout spawning habitat mapping.</u> (GLIFWC - exploratory)

- Comprehensive substrate mapping in nearshore reservation shoreline in Lake Superior and in on-reservation tributaries. (GP - commitment) (RC - commitment)
- Physical Habitat Classification of Nearshore Waters of Thunder Bay and Black Bay. (OMNR - exploratory)

3. Develop and maintain a complete, comprehensive database of important habitat information including Geographic Information System (GIS) data to ensure basinwide access to data.

- Develop a GIS database of mid-scale geographic and habitat data for use in mapping habitat conditions. (MN DNR - commitment)
- Utilize existing data, prepare a GIS map identifying known spawning locations of native fish species in Lake Superior and its tributaries. (GLIFWC - exploratory)
- Distribute draft habitat database to managers in the basin to fill data gaps and identify additional sites.
- Incorporate data on habitat impairments into GIS database for Lake Superior.
- Map identified Endangered Species Act mandated designated critical habitat in the Lake Superior watershed for all federally listed species.
- Piping plover critical habitat mapping. (FWS - commitment)
- Map locations of threatened and endangered species in the 1854 ceded territory in Minnesota. (1854Auth. - commitment)
- Identify and map habitat for native species of economic and cultural importance, including lake sturgeon, lake trout, lake whitefish, wild rice, ginseng and others where appropriate.
- Develop and distribute decision support tools using geographic information systems (GIS) data and models. (MN DNR - commitment)
- GIS map and database relating fish communities to habitat for eastern Lake Superior. (COTFMA - commitment)
- Develop two display kiosks through the Lake Superior Decision Support System project to provide information about Lake Superior habitat status, trends, stressors and restoration/remediation/maintenance activities. (MN DNR)
- Develop and distribute county- scale GIS data for land use planning in Marquette Co. (MI DNR - commitment)
- Establish a spatial information resource center in Marquette. (MI - commitment)
- Identify and map wetlands on the reservation. (KBIC - commitment)

4. Complete comprehensive habitat assessment and aquatic community surveys to identify important habitat sites in tributary streams, and inland lakes of the watershed.

- Conduct a comprehensive hydrologic assessment of the Whittlesey Creek watershed.
- Little Rapids biotic study would assess biological conditions in a remnant rapids system in the St. Marys River. (St. Marys RAP - exploratory)
- Aquatic community survey in Michigan tributaries. (MI - commitment)
- Regional Environmental Monitoring and Assessment Project (REMAP) in coastal wetlands on the U.S. side. (EPA - commitment)
- St. Louis River habitat plan. (St. Louis River RAP - commitment)

5. Identify sites that meet the criteria for important habitat. This includes integrating cooperative, long-term habitat inventory and assessment efforts.

- Inventory and assessment on the Fond du Lac reservation. (FdL - commitment)
- Identify areas with the hydrologic and physical characteristics to support creation of new wetlands and rapids in the St. Marys River. (St. Marys River RAP - exploratory)
- Duluth Area Natural Resources Inventory. (City of Duluth - commitment)

6. Identify additional important habitat sites in areas where data is lacking, utilizing expert knowledge.

- Conduct expert surveys in Michigan to identify additional important habitat sites.
- Conduct expert surveys in Ontario to identify additional important habitat sites.

7. Utilize NOAA/Coast Guard ESI maps to determine whether sites meet criteria for important habitat.

8. Implement conservation actions to maintain and restore habitat function and structure at sites that meet the criteria for -important habitat sites.-

- Pine barrens management/sharp tailed grouse habitat in Wisconsin. (WI DNR, GLIFWC - commitment)
- Protect remnant old growth forest and restore/rehabilitate high potential old growth areas.
- Protect remnant rapids in the St. Marys River from further reduction and degradation and maximize the productive capacity of rapids habitat. (St. Marys River RAP - exploratory)

9. Evaluate Natural Heritage inventory techniques and develop appropriate methods to address differences in techniques.

10. Assess impacts to habitat at a basinwide scale from current and historic sources of degradation.

- Review the list of degraded waters on the Clean Water Act, Section 303D list (waters that do not meet the standards of fishable, swimmable, drinkable) for areas with habitat impacts. Assess impacts to habitat on a basinwide scale.
- Inventory and review Superfund sites in the basin for habitat impacts; assess impacts to habitat on a basinwide scale.
- Review RAP Areas of Concern for habitat degradation impairments; assess impacts to habitat on a basinwide scale.
- Mission Creek waste dump assessment would include a hydrogeological and waste characterization study and a feasibility study for waste removal. (St. Marys River RAP - exploratory)
- Review and revise where necessary, report on habitat impacts of major dischargers for sites that have documented degradation of habitat.
- Investigate additional sources of information for habitat impairments such as identified minor dischargers and historical dischargers. Conduct bioassessments in areas with suspected habitat impairments.
- Conduct bioassessments in areas with suspected habitat impairments based on information from 303(d), Superfund, RAPs, major and minor discharger sites, and other sources.

- Bioassessments in the Waishkey River Watershed of the St. Marys River Area of Concern. (BMIC - commitment)
- Assess the impact of beaver dams as part of the bioassessments conducted in wadeable streams of the basin (MDEQ - commitment)

11. Design and implement projects to address lost ecosystem functions at degraded sites identified by the actions under Strategy 10.

- Michigan stamp sands restoration locate and stabilize stamp sand deposits in the Keweenaw peninsula. (Houghton/Keweenaw NRCS - exploratory)
- Dam removal or installation of fish passage facilities where appropriate.
- Ensure that habitat projects at degraded sites promote citizen stewardship of areas of important habitat where appropriate.
- Little Rapids Habitat restoration in the St. Marys River. (St. Marys River RAP - exploratory)
- Twenty-first Avenue Channel habitat restoration, St. Louis River. (MN DNR - exploratory)
- Total Maximum Daily Load (TMDL) allocations for water bodies that are not attaining designated uses (303[d]). (MDEQ - exploratory)

12. Implement actions to reduce stressors and eliminate sources of stress to important terrestrial and aquatic habitat sites.

- Identify the primary stressors and sources of stress to important habitat sites in tributaries and inland lakes.
- Deer herbivory impacts in Lake Superior forests. (GLIFWC - exploratory)
- Feasibility study for a lamprey barrier on the Bad River. (BR, FWS - commitment)
- Quantify impact of shoreline development and develop a tool for local governments to monitor and assess impacts.
- Western Upper Peninsula Sediment Reduction project would reduce runoff through bridge replacement, establishment of runoff ditches, stabilization of banks etc. (USFS, Ottawa - exploratory)
- Woody debris project on the Middle Branch of the Ontonagon River to improve trout habitat (USFS, Ottawa - exploratory)
- Encourage walleye recovery in the Bar River by mitigating effects of land use practices upstream of historic spawning grounds. (St. Marys River RAP - exploratory)

13. Participate in activities to develop an understanding and encourage agreement on the status and trends of habitat conditions in the basin.

14. Participate in activities to develop an agreed upon set of goals and targets for sustainable, landscape scale habitat conditions in the basin.

15. Maintain a list of potential grant sources that apply to the Lake Superior basin and develop a network of support for funding habitat projects.

16. Develop habitat protection plans for sites of important fisheries habitat based on rehabilitation plans developed by the Great Lakes Fishery Commission (Lake Trout, Lake Sturgeon, Coaster Brook Trout, and Walleye).

- Habitat Requirements of Coaster Brook Trout in Nipigon Bay. (OMNR - commitment)
- Status of Walleye Stocks and Habitat Quality in Batchawana Bay and the St. Marys River. (OMNR - exploratory)

17. Implement habitat recommendations contained in the Great Lakes Fishery Commission-s fish community objectives and rehabilitation plans.

18. Develop riparian guidelines for long term ecological maintenance, incorporating information about potential vegetation and best management practices, and addressing regionally important habitat considerations.

- Distribute, promote and train local governments, industries and certification groups in the use of the guidelines.

19. Identify important riparian and nearshore terrestrial habitats and develop and implement plans to protect and restore riparian zones, environmental corridors, and buffer zones.

- Little Two Hearted River restoration would stabilize stream banks and realign a roadway. (Luce County Road Commission - exploratory)
- Ashmun Creek bioreserve. (St. Marys RAP - exploratory)
- Shoreline riparian assessment in Marquette County. (MI DNR, Central Lake Superior Watershed Partnership - commitment)
- Whittlesey Creek restoration would complete collection of hydrologic information for use in groundwater models of the watershed. (FWS - commitment)
- Tree planting project in the riparian zone along Fond du Lac creek. (FdL - commitment)
- Acquisition of Lake Superior shoreline, connected wetlands, riparian areas and associated uplands. (USFS, Ottawa - exploratory)
- Miller Creek watershed restoration. (MN DNR - commitment)
- Cypress River Rehabilitation. (OMNR - commitment)
- McIntyre River Habitat Inventory. (OMNR - commitment)
- Marathon Marina Development - Habitat Enhancement/Sediment Remediation. (OMNR - exploratory)
- Thunder Bay Hospital Site Development - McIntyre River. (OMNR - commitment)

20. Apply special designations protections for areas of identified important habitat.

- Evaluate public lands for potential special designations, incorporate recommendations into management plans as plans are revised.
- Assess tributary watersheds for suitability for special designations including Natural Rivers designation, Natural Heritage Rivers, Wild and Scenic Rivers, State Natural Area, Research Natural Area, Outstanding Reservation Resource Waters, etc.
- Assess terrestrial areas for suitability for special designations including State Natural Area, Research Natural Area, etc.
- Develop recommendations for designation of most significant habitat sites.
- Plan and implement a network of protected representative ecosystems across the Lake Superior basin in order to establish baseline areas for terrestrial wildlife monitoring and research (U.S. side) (USFS - exploratory)

- Protecting small, significant areas of ecological significance in the central Lake Superior basin. (Central Lake Superior Land Conservancy - exploratory).
- Develop and implement a designation -Area of Quality- to complement the -Area of Concern- designation in the Great Lakes Water Quality Agreement.
- Keweenaw Bay Indian Community will establish the reservation as a Conservation District. (KBIC - commitment)

21. Incorporate protection and restoration of important habitat into land use plans.

22. Participate in the development of Great Lakes basin wide ecological classifications (i.e., Ecological Classification Systems / Environmental Land Classifications, aquatic community classification, lake ecosystem section classification) where they do not already exist to ensure that the unique character of Lake Superior is represented.

23. Restore and protect conifer forests in appropriate upland and stream corridors.

- Re-establish cedar trees along the Bad River and evaluate the use of enclosures to keep deer from browsing the young trees. (BR - commitment)

24. Implement habitat recommendations contained in the North American Waterfowl Management Plan.

- Landscape scale coastal wetland project in MN. (FWS - exploratory)
- Reconstruct the Sylvester dam and enhance the associated impoundment. (USFS, Hiawatha - exploratory)
- Northern Wood Marsh Rehabilitation. (OMNR - commitment)

25. Restore and protect habitat for native species of economic and cultural importance, including lake sturgeon, lake trout, lake whitefish, wild rice, ginseng and others where appropriate.

- Rice Portage restoration project includes aquatic plant management and water control activities to enhance wild rice. (FdL - commitment)
- Install a water control structure to enhance wild rice and waterfowl habitat at Roubillard Creek. (KBIC - commitment)
- Waterfowl and wild rice enhancement projects at Sand Point Sloughs and Pinery Lakes. (KBIC - commitment)

26. Implement habitat recommendations of the Great Lakes Panel on Aquatic Nuisance Species.

- Purple loosestrife and exotic plant control. (GLIFWC - commitment)
- Purple loosestrife control program. (MN DNR - commitment)

27. Implement conservation actions recommended in watershed plans, reservation Integrated Resource Management Plans, Lake Management plans and ecoregional conservation plans.

- Develop watershed management plans for Lake Superior drainages that include "Best Management Practices" for restoring and maintaining ecological function and structure.

- Develop habitat components of Lake Superior guidance for watershed management planning.
- Anna River restoration would identify and prioritize critical areas and identify best management practices for remediation. (Munising Bay Watershed Council - exploratory)
- Creation of Mission Creek Watershed Association. (St. Marys River RAP - exploratory)
- Develop inland lake watershed management plans for inland lakes supporting significant biological diversity or important habitat. Plans should include habitat restoration/rehabilitation/ protection for important habitat features and processes.
- Develop Integrated Resource Management Plans for reservation lands. (FdL - commitment), (KBIC - commitment), (RC - commitment)
- Develop and implement site conservation plans for known sites of important habitat.
- Red Clay Plain Soil Restoration and Erosion Reduction would reduce flow and stabilize red clay soils by converting cover types from hardwood or popple to conifer. (WI DNR - exploratory)
- Work with local partners to develop ecoregional conservation plans for each sub-section in the Lake Superior watershed.
- Chocolay River restoration would include stream restoration, stream crossing improvements, erosion control and public education. (MIDNR - exploratory)
- Yellow Dog River restoration would map critical areas in the watershed where erosion control is necessary. (Yellow dog River Preservation Society - exploratory)
- Munuscong River watershed plan implementation would stabilize stream banks in eroded areas and study sediment removal options. (St. Marys River RAP - exploratory)
- Dead River watershed plan implementation.
- Identify conservation priority areas within the Stony Brook watershed and implement projects to protect and enhance the watershed. (FdL - commitment)
- Reduce sedimentation in Zepa Creek and conduct water quality monitoring to verify results. (KBIC - commitment)
- Implement remedial recommendations contained in the Watershed Development Plan for Bennett and West Davignon Creeks. (St. Marys River RAP - exploratory)

28. Identify priority research needs and research gaps, and develop appropriate projects to address those needs and gaps.

- Evaluate restoration projects and restoration ecology research to link successes to specific restoration actions.
- Identify disturbance regimes and ranges of natural variation within disturbance regimes.

29. Participate in activities to develop a regional set of best management practices for forestry.

- Review compliance with Best Management Practices for forestry, road building and recreation and recommend corrective actions where needed.
- Engage citizens and loggers in cooperative learning about forestry practices. (Michigan State University - commitment)

30. Implement the habitat recommendations contained in federal threatened and endangered species recovery plans. Restore and protect habitat for state, tribal, and provincially listed species.

- Inventory Endangered Species Act (ESA) mandated -Recovery Plans- that need to be completed for threatened and endangered species in the Lake Superior Basin.
- Complete ESA mandated -Recovery Plans- for federally listed (U.S.) species where those plans do not already exist.
- Restore and protect colonial waterbird habitat where appropriate throughout the basin.
- <u>Conservation plan for terns and plovers - acquisition and restoration.</u> (WI DNR - exploratory)

31. Institute a long-term, basin wide sampling program to implement habitat indicators.

- Develop and coordinate monitoring protocols, sampling procedures, and data handling processes for selected "Best Bet" indicators.
- Test monitoring protocols in basin-wide indicator applications.
- Evaluate monitoring protocols and revise based on test results.
- Participate in activities to develop agency support for basin-wide implementation of indicators.
- Participate in the development of methodologies to incorporate Great Lakes indicators into Lake Superior monitoring programs.
- <u>Inventory and assessment of snapping turtle populations, habitat and evaluation of use as an indicator, using GIS.</u> (GLIFWC - exploratory)

32. Provide information to local governments and landowners about the linkages between land use and ecosystem health.

- Inventory the information available to landowners and local governments on the impacts of land use on streams and lakes.
- Identify existing information publications related to impacts of landscape change and assess the effectiveness of these publications.
- Develop and distribute an information/communications piece to summarize the linkages between and use and aquatic community well being in the basin. This piece will include contact information for landowners and local decision makers as well as directions for getting more information.
- <u>Develop an informational land use brochure targeted to landowners on the Fond du Lac reservation.</u> (FdL - commitment)
- Develop and distribute a series of information publications focusing on providing information to landowners/managers and local governments about how to assess long-term effects and plan for reducing the negative effects of these changes.
- Identify a potential suite of incentives to implement that will encourage local governments and landowners to foster healthier land-water linkages.

- Identify the audiences most in need of information related to cumulative impacts of landscape change, habitat fragmentation and habitat destruction.

33. Focus attention on environmental issues through education related to restoration, rehabilitation and maintenance.

- Develop an information fact sheet on improving public participation in restoration/rehabilitation projects and distribute to practitioners in the basin.
- Provide interactive education at the Northern Great Lakes Visitor Center. (FWS - exploratory)
- Conduct a natural history speaker series at the Northern Great Lakes Visitor Center. (FWS - exploratory)

34. Hold workshops on public participation in environmental issues in the basin. (See also, Community Awareness Review under the Sustainability tab)

35. Produce a motion picture or IMAX film on Lake Superior.

36. Provide opportunities for researchers and resource managers in the Lake Superior basin to identify restoration/rehabilitation goals and priorities, network, learn from each other and generate new ideas and develop strategies for real problems and issues.

- Hold a Lake Superior Restoration/rehabilitation and Protection conference geared at ecological restoration/rehabilitation.

6.2.1 Habitat Committee Next Steps

The previous portion of this chapter sets out a number of goals and principles, strategies, actions and projects that will be important for governments, communities and individuals to undertake in order to adequately restore and protect habitat in the Lake Superior basin. There are also actions that the Habitat Committee of the Lake Superior Binational Program (LSBP) proposes to undertake for the next two years and beyond that support these goals and principles.

An important role for the Habitat Committee is to facilitate discussion about habitat status, trends, stresses and sources of stress to the Lake Superior basin in order to achieve consensus for coordinated action. These discussions should include the diversity of natural resource professionals and the growing number of citizens and environmental groups focused on habitat issues. Basin wide consensus on these issues will provide a basis for resource managers and the public to prioritize and balance actions that will protect and restore habitat and the ecological health of the watershed. For example, land management for white-tailed deer and land management for regrowth of northern white cedar must be balanced so that deer and cedar are represented on the landscape in a way that reflects a healthy and productive ecological system. Priority activities to reach the desired conditions can then begin.

To begin developing the necessary basin wide consensus, the Habitat Committee proposes using the habitat sections of LaMP 2000 (along with the terrestrial, and aquatic sections as appropriate) as a starting point for discussion to develop consensus among natural resources professional for regional status, trends, stresses and sources, monitoring and indicators. Actions to accomplish this may include workshops, presentations or other meetings and discussion forums.

It will be, over the next two years, crucial to communicate to the public the broad range, impact and cumulative effects of the habitat protection and restoration efforts under way throughout the basin. This will be accomplished by magazine articles, video and other media outlets. This action necessitates continuing to develop and maintain a comprehensive database of projects that are ongoing, proposed and completed and maintaining and expanding the committee?s web site (http://www.d.umn.edu/~pcollins/lsbp).

The Committee has developed an important information resource with the Lake Superior Decision Support project (http://oden.nrri.umn.edu/lsgis). This resource will require work to expand and continue to deliver important geographic information about the watershed at scales that enable basin wide assessment, mapping and coordination across agency and geographic borders.

Ensuring a thorough and comprehensive public review and comment on the LAMP 2000 report, effectively and efficiently responding to public comments and integrating necessary improvements into LaMP 2002 will be a priority for the Committee over the next 2 years. Several actions are necessary to ensure that public comments are integrated in the LaMP process at the same time as agency consensus is being developed. Coordination between the LSBP and other organizations such as the Lake Superior Ecosystem Cooperative, and the Great Lakes Fishery Commission, for example will be important for ensuring that regional priorities are developed in a way that maximizes the effectiveness of their implementation.

6.3 PROJECTS AND RESULTS

There have been, and continue to be many projects to identify, protect and restore habitat in the Lake Superior watershed. Compiling and summarizing these projects is a daunting challenge. This portion of the LaMP for Habitat represents the results of that challenge to date. This compilation of project summaries was developed to document the work being done throughout the watershed that furthers the goals and strategies identified in the previous chapter of this LaMP. Where information was available, project summaries were developed. Following the project summaries is a list of projects for which summary information is still needed. This report provides an encouraging picture of the many local and basin-wide efforts that have been undertaken. It is not a complete listing of all such projects. Development of this information will continue and can serve to provide a reference to natural resource managers and the Lake Superior community.

Projects have been placed into one of 5 categories. They are 1) Habitat Restoration and Rehabilitation, 2) Special Designations and Acquisition, 3)Watershed Management and Forest Stewardship, 4) Monitoring, Assessment and Inventory, and 5) Education and Public Involvement.

Habitat restoration and rehabilitation projects include those projects that implement physical activities that improve habitat features or processes and benefit native plant or animal communities or species as the result of direct management actions.

Special designations and acquisition projects include activities that protect habitat features or processes through designating lands as protected areas, management areas, or other formal designation. Projects that acquire private lands for public agency management (or in some cases, private conservancy management) for the purposes of protecting or restoring important habitat are also included.

Watershed management projects and forest stewardship projects include efforts on a broad, landscape scale to establish and implement watershed wide or landscape level goals, prioritize actions and protect important habitat. Often these efforts include habitat restoration, designations, monitoring, inventory and public involvement actions that are critical to the success of the management projects.

Monitoring, assessment and inventory projects include a wide variety of efforts to provide key information that enables improvements in management decisions, prioritization of actions, and identification of important habitat areas. Key research questions may also be addressed by projects in this category.

Education and public involvement is often included as part of the necessary set of actions undertaken in all projects. Because human decisions are responsible for both positive and negative changes in habitat conditions, education and public involvement may be the best way to protect or restore habitat. Projects that focus primarily on these activities are listed under this category.

Habitat Restoration and Rehabilitation

1. Munuscong Lake Dike Restoration, St. Marys River
2. Stirlingville Bridge Clean Up, Munuscong River
3. Wild Rice Seeding (Spectacle Lake and Back Bay, Bay Mills Res.)
4. Hearding Island Native Plant Community Restoration, Duluth, MN
5. Grassy Point Wetland Restoration, Duluth, MN
6. Sugarloaf Cove Wetland Restoration, MN
7. Conifer Restoration Project, Bad River, WI
8. Boreal Forest Restoration Demonstration Project, WI
9. Dam Removal Project on Iron River, Iron River, WI
10. Rehabilitation of degraded walleye spawning habitat -Thunder Bay, Ontario
11. Revival of spring-fed tributary stream - Nipigon, Ontario
12. Creation of embayments to restore productive littoral habitat - Thunder Bay, Ontario
13. Building a better breakwall - Red Rock, Ontario
14. Cypress River Rehabilitation
15. Northern Wood Marsh Rehabilitation Marsh reclamation - Thunder Bay, Ontario
16. Restoring productive habitat at a creek mouth - Thunder Bay, Ontario
17. Shoreline alteration to restore habitat diversity at a floodway - Thunder Bay, Ontario

18. Redesign of waterfront park to protect and enhance shoreline - Thunder Bay, Ontario
19. Improving salmonid access to spawning habitat - Thunder Bay, Ontario
20. Treatment of bacterial contamination at local beach - Thunder Bay, Ontario
21. Enhancing aquatic habitat to bring back walleye - Nipigon, Ontario
22. Restoration of Biological Diversity in Forests of Two Great Lakes National Parks
23. Incorporating habitat protection into development plans - Thunder Bay, Ontario

Special Designations and Acquisition

24. Keweenaw Threatened, Keweenaw Preserved
25. St. Louis River Stream Bank Protection Project, Oliver, WI
26. Park Point Scientific and Natural Area
27. St. Louis River Management Plan and Land Acquisition Project, MN

Watershed Management and Forest Stewardship

28. Miller Creek Restoration
29. Chocolay River Watershed
30. Central Lake Superior Watershed Partnership
31. Torch Lake Remedial Action Plan (RAP)
32. Whetstone Brook Watershed
33. Clay Lake Plain Ecosystem Project
34. Knife River Watershed Education Project, Two Harbors, MN
35. Northern Rivers Initiative, WI
36. Two-Hearted River Watershed Landscape Management Project
37. Shoreline Management Plan for Lake Superior Sault Ste. Marie District
38. Nemadji River Watershed Project
39. Midway River Watershed Project
40. Sucker/French/Talmadge/Lester Watershed Forest Stewardship Project
41. Skunk Creek Watershed
42. Grand Marais Watershed
43. Flute Reed River Watershed Forest Stewardship Project
44. Miller Creek Watershed Project
45. Development of a Water Management Plan " Nipigon, Ontario
46. Watershed Management Plans " Thunder Bay and Sault Ste. Marie, Ontario
47. Minnesota Point Protection Project
48. Lake Superior Decision Support Project
49. Goulai's River Watershed Project
50. Michigan Upper Peninsula Coastal Wetland Project

Monitoring, Assessment and Inventory

51. Fish Habitat Mapping Project for Whitefish Bay/Upper St. Marys River
52. Quantification and distribution of bottom substrates in Tahquamenon Bay, Lake Superior, and use of the substrates by several fish species
53. Mapping Lake Trout Spawning Habitat Along Minnesota's North Shore, MN

54. Duluth Area Natural Resources Inventory, Duluth, MN
55. Habitat Plan for the St. Louis River RAP AOC, Duluth, MN
56. Shoreline Habitat Survey of Batchawana Bay
57. Marsh Monitoring Program, Basin wide
58. Habitat survey of heavily fished rainbow trout stream ‟ Thunder Bay, Ontario
59. Habitat requirements of coaster brook trout in Lake Superior ‟ Nipigon, Ontario
60. Sea Lamprey control efforts in St. Marys River
61. Risk Analysis of the Aquatic Resources in Pictured Rocks National Lakeshore
62. Superior Coastal Wetland Initiative Phase I
63. Habitat requirements of lake sturgeon in the Kaministiquia River - Thunder Bay, Ontario

Education and Public Involvement

64. Keeping Nature in Your Community Workshop, Duluth, MN
65. Adopt-A-River Program, MN
66. Minnesota's Lake Superior Coastal Program (MLSCP)
67. Community Education about Nonpoint Pollution and Exotic Species
68. Community cleanup of waterfront property ‟ Thunder Bay, Ontario
69. Deer Marsh Wetland Protection and Public ed. MI
70. HabCARES
71. Partners for Fish and Wildlife

1 Title: Munuscong Lake Dike Restoration, St. Mary’s River

Strategy: 11

Objective: A 4-mile long dike system with three impoundments totaling 750 acres was constructed by the Michigan Department of Natural Resources Wildlife Division in 1965-66 to restore an emergent marsh in Munuscong Bay along the shore of Munuscong Lake. This effort was not measurably successful as it prevented exchange of water and nutrients between the bay and the lake, blocked access to diked areas by spawning fish, and provided predatory furbearers enhanced access to the coastal marsh. To correct this situation a new project was undertaken to modify the dike system to increase water exchange between the Munuscong Bay and Munuscong Lake.

Results: The dike system was contoured to lower and widen the tops and sides. Three 400-foot spillways and five 100-foot spillways were installed at an elevation to allow water exchange during high-water periods. Although water levels have been low since the project was completed, water and nutrient exchange has occurred during periodic seiche events. The increased supply of oxygenated water should accelerate detritus breakdown and further nutrient exchange. No empirical evaluation has been done but observers report increased usage of the restored area by fish and waterbirds. Future high water cycles are expected to naturally erode the remnant dikes and create islands that will provide safer nesting sites for waterbirds.

Contact: Rex Ainslie, Michigan Dept. of Natural Resources, Wildlife Division, Sault Ste. Marie, MI. (906-635-6161)

Partners: Michigan Department of Natural Resources, Tri-County Wildlife Unlimited

Funding: Michigan Department of Natural Resources - $4,000

Status: Completed

2 Title: Stirlingville Bridge Clean Up, Munuscong River

Strategy: 11

Objective: Remove bridge pilings in the river at three acute locations. The pilings had been in the river since 1909 and had collected a great deal of debris over the course of the years and almost completely blocked the river in several locations. The river had been undercutting the banks in those areas sending clay down the river and into the mouth of the Munuscong Bay. In the Bay the clay has collected to form an underwater island in an area that at one time had a water depth of 8 feet. The water depth as a result of the clay intrusion is now only 2 feet deep.

Results: The Munuscong River Watershed Association (MRWA) sponsored a volunteer clean up of the river and the Chippewa County Road Commission used heavy equipment to clean up three sites, removing the pilings and collected debris and sediment islands. The MRWA temporarily planted seed on raw banks at three sites. In the future, riprap, geothermal blanket and gravel will be placed at the site. This will help prevent further bank erosion during spring floods and the gravel will act as an inducement to fish for spawning.

Contact: Diane Serra, Chairperson, Munuscong River Watershed Association at (906) 647-6108 or kodie1@sault.com.

Partners: Pickford Public Schools, Chippewa County Road Commission, Pickford Feeds and Farmer Charlie Pennington.

Funding: Seeking funds to place geo-thermal blanket, rip rap and gravel to stabilize banks at the three bridge-piling sites.

Status: Ongoing until stabilization funds are secured to complete the project.

3 Title: Wild Rice Seeding

Strategy: 11

Objective: Wild rice seeding of local areas was initiated in 1993 on the Bay Mills Indian Reservation. Although there is very little historical documentation of wild rice on the Reservation, wild rice is a very important plant “culturally, as well as nutritionally” for the Ojibwe people. Community members are interested in establishing local rice beds for waterfowl use and eventually for tribal use.

Results: Two areas on the reservation have been seeded: Spectacle Lake in 1993-1998 and Back Bay since 1995. Seeding in Spectacle Lake has been discontinued because of the poor growth observed there. The wild rice beds in Back Bay appear to be improving and expanding.

Contact: Bay Mills web site bmic.net under the Biological Services heading. Ken or Ann Gebhardt, 12140 West Lakeshore Drive, Brimley, MI 49715. (906) 248-3241.

Funding: Bureau of Indian Affair's Circle of Flight Program

Status: ongoing until rice bed are established, possibly 4-8 years

4 Title: Hearding Island Native Plant Community Restoration, Duluth, MN

Strategy: 11

Objective: Hearding Island is a 32acre island created from the sandy material dredged from the shipping channels in the estuary during the early 1930's. The island was important for colonial waterbirds such as Common Terns and Piping Plovers after it was created. As vegetation encroached on the open, sandy nesting habitat preferred by the terns and plovers, they moved to other, more recently created islands or points. The objective of this project was to help establish or maintain White Pine/Red Pine forest with scattered tamarack in some lower and wetter areas, aspen-birch forest or dry alder shrub land, and beach dune plant communities.

Results: Volunteers helped plant 800 white pine trees, 700 red pine trees and 400 tamarack trees in the areas to become conifer dominated forest. In addition, volunteers helped control exotic plants by pulling tansy, an invasive weed of European origin, from the dune community and removing litter and debris form the island.

Partners: Park Point Community Club, St. Louis River Citizens Action Committee, Minnesota DNR, and community volunteers.

Contact: Pat Collins, MnDNR, 218-834-6612, patcollins@dnr.state.mn.us

Funding: $7,000 grant from U.S. Environmental Protection Agency's Great Lakes National Program Office. This was matched by a substantial volunteer effort in management planning and tree planting.

Status: Completed 1996

5 Title: Grassy Point Wetland Restoration, Duluth, MN

Strategy: 11

Objective: Grassy Point has long been identified as an important habitat area in the Duluth Superior Harbor. Bird monitoring reports and long-term fisheries monitoring stations in the harbor recorded its importance for a variety of species due to its complex mosaic of wetland habitat types. Historically, the site served as a location for turn-of-the-century saw mills that left a legacy of waste wood throughout the wetland. In places this wood waste was more than 16 feet deep and hindered the movement of fish into a trout stream that feeds the wetland. In other places the wood was preventing the growth of aquatic vegetation.

Results: Approximately 11,000 cubic yards of waste wood was removed from the wetland to improve hydrology and conditions for wetland vegetation, fish and waterfowl. Access to the site was improved through upgrades to the roadway, providing a parking area and extending a bike trail from a nearby park.

Partners: U.S. EPA, Minnesota Department of Natural Resources, City of Duluth, St. Louis River Citizens Action Committee.

Contact: Pat Collins, MnDNR, 218-834-6612, patcollins@dnr.state.mn.us
http://www.dnr.state.mn.us/ebm/ebm_works/lakesup1.htm,
http://www.d.umn.edu/~pcollins/grassy.html

Funding: Grant from U.S. Environmental Protection Agency's Great Lakes National Program Office for $170,000. Matching funds form the City of Duluth and the Minnesota DNR.

Status of the project: Completed March 1996

6 Title: Sugarloaf Cove Wetland Restoration, MN

Strategy: 11

Objective: Sugarloaf Cove is a unique site on the Lake Superior shore. Part of the site was purchased in 1987 from The Nature Conservancy for a Scientific and Natural Area (SNA) in recognition of the outstanding bedrock shore geological features. Development and land modifications have resulted in a land cover that is very different from that of pre-settlement times.

Coastal wetlands along Minnesota's Lake Superior shore tend to be small and uncommon. Historical records indicate that a 2-3 acre coastal wetland existed at the Sugarloaf site before being filled in to provide better access to the beach and a larger log landing area. Native vegetation communities have been converted to communities dominated by non-native species, younger age classes or have been greatly simplified.

A recent land transaction has enlarged the size of the SNA and transferred other lands to the Sugarloaf Interpretive Center Association (SICA). This provides an opportunity to combine a unique habitat restoration project with an emerging educational and interpretation program.

Results: Restoration of a wetland filled in the 1930s and the associated upland plant community. Excavation of a 1+ acre wetland basin, removal of building debris, closure and filling of old access road and regrading of upland areas completed in fall of 1999. Planting of native species is scheduled for May 2000.

Partners: Minnesota Department of Natural Resources, Sugarloaf Interpretive Center Association.

Contact: Pat Collins, MnDNR, 218-834-6612, patcollins@dnr.state.mn.us

Funding: $138,500 grant from U.S. Environmental Protection Agency's Great Lakes National Program Office, match from, Minnesota Department of Natural Resources, Minnesota Conservation Partners Grant Program, and Sugarloaf Interpretive Center Association.

Status: Ongoing. Scheduled for completion in September, 2000.

7 Title: Conifer Restoration in the Bad River Watershed

Strategy: 11

Objective: This two-year project engaged work study students, volunteers, and internship crews in conifer (white cedar, hemlock, and white pine) planting and enclosure-building. Five methods of conifer regeneration were tested at sites across the Chequamegon region. As a small pilot study, enclosures were built to assess deer browse damage to conifers.

Results: The results were the establishment of a tree planting program and assessment of success as part of Northland‟s regular curricular activities. A program for Northland College undergraduates was begun to implement a multi-year conifer restoration project. Although ongoing, the project is expected to help restore the biological integrity and ecological functioning in headwater streams throughout the watershed. This will be a model for student and volunteer-based conservation efforts.

Partners: Bad River Tribe, Wisconsin Department of Natural Resources, The Nature Conservancy

Contact Information: Northland College, Ashland, WI 54806, 715-682-1550

Funding: $46,700 grant from EPA Great Lakes National Program Office; $11,400 Northland College

Status: Grant work is completed, however, studies are continuing and interpretable results will not be available for 3-4 years.

8 Title: Boreal Forest Restoration Demonstration Project

Strategy: 11

Objective: This project delineated a fifty square kilometers demonstration area and three separate sixteen square kilometers sub-demonstration areas, which are the largest blocks of boreal forest or second growth with boreal characteristics left on the reservation, as part of a long-term terrestrial monitoring program to be maintained by the Bad River Tribe of Lake Superior Chippewa. In addition to a long-term monitoring plan, the objectives of this project are to protect wolf den and rendezvous sites, to determine wolf movement patterns, to enhance coniferous vegetation in order to spread deer back out to a larger range in order to lessen the impacts on herbivory, and to maintain an educational/outreach program to communicate about the project.

Results: This project is in progress.

Partners: National Wildlife Federation

Contact Information: Bad River Band of Lake Superior Chippewa, Natural Resource Department, P.O. Box 67, Odanah, Wisconsin, 715-682-7123

Funding: $100,000 grant from EPA Great Lakes National Program Office; $28,353 Bad River Tribe

Status: In progress.

9 Title: Dam Removal on Iron River

Strategy: 11

Objective: This project concerns the regulation of the Orienta Falls Dam near the mouth of the Iron River, specifically the regulatory approval of a request by the dam owner to remove the dam. The present owner considers the costs to repair and upgrade the facility not justifiable in terms of economic benefit and they have been unable to find a new owner. The Wisconsin Department of Natural Resources has approved the permit and the dam is expected to be removed during the summer of 2000.

Results: Restore both natural scenic beauty to the site and a free flowing river system to allow migration of anadromous fish into the river system.

Contact: Ted R. Smith, Water Program Supervisor, Lake Superior Basin, 1401 Tower Avenue, Superior, Wisconsin 54880, (715) 395-6911

Funding: not applicable

Status: Ongoing, once the dam is removed, WI DNR will begin construction of a lamprey barrier to protect the Iron River watershed from undesirable exotic species and to protect Lake Superior from increased reproduction of parasitic sea lamprey.

10 Title: Rehabilitation of degraded walleye spawning habitat - Thunder Bay, Ontario

Strategy: 11

Objective: The mouth of the Current River has been identified as exceptionally valuable fish habitat in the Thunder Bay area as it provides both spawning and nursery grounds for one of the few remaining, naturally reproducing walleye stocks in Lake Superior. Over the past 130 years, spawning habitat has been lost or modified in the Current River by the effects of a silver stamp mill (1870s), saw mill (late 19^{th} century), road and railway construction (late 19^{th} to early 20^{th} century), river impoundment for water management (~1905), and through the construction of a boat launch and docking facility (1984). This rehabilitation project was designed to compensate for habitat removed during dredging activities by augmenting remnant, and creating new walleye spawning areas.

Three sites were selected for enhancement in the Current River estuary covering an area (1,700 m^2) of approximately half the size of that destroyed by previous dredging activities. Two of these sites were downstream extensions of remnant spawning areas in faster flowing sections of the estuary. A third site was created closer to the river mouth where walleye spawning has been observed in the past. Each area was cleared of debris and clean substrate, in the form of gravel, cobble, and boulders, was added without disturbing existing spawning habitat.

With the completion of this project in December 1991, a monitoring program was established to estimate walleye abundance, levels of spawning activity, and the frequency of successful spawning events. Although there was no initial change in abundance of adult walleye, the area of habitat over which walleye successfully spawned increased. Viable eggs were found in both the historic and newly created lotic spawning habitat. Further assessments have been scheduled for the years 1999 to 2000 to evaluate the success of this rehabilitation project.

Partners: Environment Canada, Ontario Ministry of Natural Resources, Department of Fisheries and Oceans, Ontario Ministry of the Environment, Lake Superior Programs Office, and the Great Lakes 2000 Cleanup Fund.

Contact: Ken Cullis, Ontario Ministry of Natural Resources, Lake Superior Management Unit, (807) 475-1375, ken.cullis@mnr.gov.on.ca

Funding: $37,500 construction, $42,000 assessment

Status: Completed

11 Title: Revival of spring-fed tributary stream - Nipigon, Ontario

Strategy: 11

Objective: Clearwater Creek is a small, spring-fed stream that flows through the Town of Nipigon and drains into the Nipigon River on Lake Superior. Over the years, the growth of the Nipigon township led to encroachment on the stream valley and degradation of the creek. The downstream end of the creek was diverted and storm water runoff from the town was discharged into the water system. A deep ravine formed by the stream channel acted as a garbage collector and over the years had become an unofficial dump site. Further bank destabilization and erosion resulted in impaired water quality, loss of habitat diversity, and the decline of a once viable brook trout fishery.

The Clearwater Creek rehabilitation strategy outlined a number of recommendations to be implemented on a watershed basis. The plan included removing debris from the creek system, diversifying instream habitat, stabilizing banks, and controlling storm water. A settling pond to remove contaminants from the urban runoff carried by this creek to Nipigon Bay and the redirection of storm sewers with step/detention pools were also part of the design.

The St. Edward's School property, situated on the banks of Clearwater Creek, was a priority site for rehabilitation as the eroding stream valley posed a safety hazard and liability concern. The proximity of the creek to the school afforded opportunities to implement educational and recreational amenities within a project aimed initially at achieving environmental objectives. With construction complete, the school is no longer in danger of tumbling into the ravine and now has an environmental park and ready made science classroom in its backyard.

Partners: Great Lakes 2000 Cleanup Fund, Ontario Ministry of Natural Resources, Ontario Ministry of the Environment, Environmental Partners Program, Nipigon Bay Remedial Action Plan, Ontario Ministry of Education and Training, North of Superior District Roman Catholic Separate School Board, and St. Edward Separate School.

Contact: Ken Cullis, Ontario Ministry of Natural Resources, Lake Superior Management Unit, (807) 475-1375, ken.cullis@mnr.gov.on.ca

Funding: $270,000

Status: completed

12 Title: Creation of embayments to restore productive littoral habitat - Thunder Bay, Ontario

Strategy: 11

Objective: The McKellar River is the middle of three short channels comprising the Kaministiquia River delta which flows into the Thunder Bay harbour. Decades of dredging for commercial ship traffic produced a straight, deep channel and a shoreline partly armoured with steel sheet piling and concrete. While the McKellar River is no longer used for commercial shipping, most of the shallow littoral zone has been eliminated leaving little in the way of habitat productivity or diversity.

Two shallow embayments were created near the mouth of the McKellar River adjacent to the Mission Marsh Conservation Area in order to increase the littoral zone and provide an additional three hectares of wetland habitat. Diverse habitats were provided with detailed bottom grading, gravel shoals, sand spits, root wads, and pocket wetlands. Additional habitat features include a mud flat for songbirds, a sand bluff for nesting bank swallows, and shallow woodland pools for amphibians. Constant circulation from wind, wave, and Lake Superior's seiche action maintains oxygen levels throughout the embayments. Trees and shrubs were also planted in areas disturbed by construction to provide soil and bank stabilization as well as food and cover for wildlife. Walking trails connect the embayments to conservation property, creating a popular recreational area on the waterfront.

Partners: City of Thunder Bay, Lakehead Region Conservation Authority, Environment Canada, Ontario Ministry of Natural Resources, Department of Fisheries and Oceans, Ontario Ministry of the Environment, Lake Superior Programs Office, and the Great Lakes 2000 Cleanup Fund.

Contact: Ken Cullis, Ontario Ministry of Natural Resources, Lake Superior Management Unit, (807) 475-1375, ken.cullis@mnr.gov.on.ca

Funding: $607,800 construction, $74,830 assessment

Status: completed

13 Title: Building a better breakwall - Red Rock, Ontario

Strategy: 11

Objective: As with many communities along the north shore of Lake Superior, the town of Red Rock is turning to its waterfront for new economic opportunities. Located on the scenic shore of Nipigon Bay about 100 km northeast of Thunder Bay, this small town has built a new kind of marina.

The standard armour stone breakwall at the Red Rock Marina was constructed with the dual purpose of providing protection for boats and increasing habitat for fish and wildlife. The berm is overlain with trees and shrubs and a walking trail winds its way along the crest. Instream structures along the inner breakwall have increased habitat diversity in the littoral zone. Shoreline works, such as log crib shelters, shallow areas for aquatic plants, boulder edgings, gravel shoals, and tree shelters, do not interfere with the operation of the marina, but enhance biological production. A gap in the breakwall, spanned by a pedestrian bridge, enhances water circulation and ensures the passage of fish. Two small islands surrounded by underwater shoals were constructed on the outside of the breakwall. The islands were planted with native trees and shrubs including white birch, white spruce, red-osier dogwood, and eastern white cedar.

Incorporating habitat features into the design of the marina demonstrates how a normally hard shoreline structure with low biological production capabilities can be transformed into a productive and connected part of the natural system.

Partners: Environment Canada, Ontario Ministry of Natural Resources, Ontario Ministry of the Environment, Great Lakes 2000 Cleanup Fund, and the Township of Red Rock.

Funding: $230,000 (cost of converting breakwall into a green parkway and enhancing the ecological productivity of the structure)

Status: completed

14 Title: Cypress River Rehabilitation

Strategy: 11

Objective: The Cypress River, which flows into Lake Superior approximately 40 km east of the township of Nipigon, provides significant spawning and nursery habitat for Lake Superior coaster brook trout and rainbow trout. In terms of fishing opportunities and quality of fishing, anglers consider this system to be one of the more important river systems along the North Shore of Lake Superior. In addition, the Lake Superior Technical Committee of the GLFC has identified this river as a key system to support implementation of the Lake Superior Brook Trout Rehabilitation Plan. Since the Cypress River supports one of the few remnant coaster brook trout stocks in Lake Superior, information collected on critical habitat and behavior patterns of this species could be critical to successful rehabilitation efforts in other Lake Superior tributaries in Ontario and the United States.

Anglers and agency representatives have been concerned with the recent erosion and river realignment that has occurred in the reach upstream of the Trans Canada Highway crossing. As a result of log jams over the last five years, the river has forged a new channel which intersects the highway approximately 40 meters from the bridge. The river currently flows parallel to the highway over this 40 meter distance. During high water events the new channel has eroded the Highway 17 embankment and has caused sediment deposition in downstream locations. The Ministry of Transportation has indicated that the highway embankment would have to be shored up with a considerable quantity of rock to prevent a major washout of the highway next spring.

Considering that the MTO proposal was a short term solution, the Thunder Bay Fly Fishing Club, in partnership with the North Shore Salmonid Work Group and MNR, developed an alternate concept to create a new 100 meter natural channel upstream from the highway. The completed channel not only improved fish habitat and reduced erosion, but relocated the river away from the highway and improved the angle at which the river flows under the Highway 17 bridge.

Phase 1, the construction of the channel, was completed in August 1999. Final bank stabilization and planting of vegetation is scheduled for July 2000.

This project directly supports the goals and objectives of the Draft Lake Superior Brook Trout Rehabilitation Plan, 1998(GLFC) and the Draft Lake Superior Rainbow Trout Management Plan, 1998 (MNR).

Partners: Thunder Bay Fly Fishing Club, North Shore Salmonid Work Group, Ministry of Transportation, Ontario Ministry of Natural Resources Nipigon District, OMNR Lake Superior Management Unit.

Contact: Ken Cullis, Ontario Ministry of Natural Resources, Lake Superior Management Unit, (807) 475-1375, ken.cullis@mnr.gov.on.ca

Funding: $30,000

Status: Ongoing

15 Title: Northern Wood Marsh reclamation - Thunder Bay, Ontario

Strategy: 11

Objective: Sediment contamination around a sawmill (Northern Sawmills, formerly Northern Wood Preservers) situated on the shoreline of Thunder Bay Harbour contributed to the International Joint Commission's identification of this location as an Area of Concern. As a result of long term seepage of wood preservatives, such as creosote and pentachlorophenol (PCP), pollutants have migrated into harbour sediments, sometimes appearing as "blankets" over the sediments or as surface slicks. Elevated concentrations of polycyclic aromatic hydrocarbons (PAHs), dioxins, and furans in the sediment have also affected water quality, degraded benthic community structure, and impaired sediment and aquatic habitat. A remediation project, referred to as the Northern Wood Preservers Alternative Remediation Concept (NOWPARC), was developed to isolate the contaminant source, remediate sediments, and enhance fish habitat in this portion of the harbour.

With this remediation plan, approximately 150,000 m^2 of lake area will be filled including a major portion of the contaminated site. To compensate for loss of lake area, wetland reclamation and sculpturing of a berm, designed to contain the contaminated sediments, will provide varied wetland habitat. Revitalizing 11,000 m^2 of land adjacent to an existing wetland (5 ha) located directly north of the sawmill will produce contours between 0-3 m in depth and provide valuable spawning, nursery, and forage habitat for a variety of fish species. In addition, a chain of small islands will be built offshore of the sawmill site creating an intercoastal wetland. The containment berm itself will incorporate a variety of embayments and other structures to provide habitat of varying depth and substrate.

Partners: Lake Superior Programs Office, Ontario Ministry of the Environment, Environment Canada, Abitibi Price Inc., Canadian National Railway Co., and Northern Wood Preservers Inc.

Contact: Ken Cullis, Ontario Ministry of Natural Resources, Lake Superior Management Unit, (807) 475-1375, ken.cullis@mnr.gov.on.ca

Funding: $210,000

Status: ongoing

16 Title: Restoring productive habitat at a creek mouth - Thunder Bay, Ontario

Strategy: 11

Objective: McVicar Creek winds through the north side of the City of Thunder Bay and empties into the harbour near a waterfront park and municipal marina. A road overpass was constructed in 1985 beside the lower 120 m of McVicar Creek as part of the park and marina complex. As a result, sand and debris eroded from the embankments, settled on the creek bottom, and accreted in the estuary. Interstices in the creek bed were filled and passage of anadromous fish to the upper reaches of this water system was impeded. A small wetland area adjacent to the creek mouth was also destroyed in the process.

Bank stabilization, substrate enhancement, and terracing of the lower portion of the road embankment were completed in 1992 to restore this urban fisheries habitat. In addition, a small crescent-shaped island was constructed in 1993 just offshore of the creek mouth. The shape of the island was designed to trap sediments transported by the creek and by lake currents in order to foster the natural development of a wetland. At the same time, the island protects the banks of the overpass from erosion. Eight rock shoals were also installed underwater in the lee of the island to provide cover, shelter, and diversity.

A “Name the Island” contest was held in local schools to raise public awareness of the project. Sanctuary Island was chosen as the winning name to reflect the role of this newly created habitat.

Monitoring efforts have indicated an increase in fish community abundance and diversity in this area. The shallow waters of the inner bay have been colonized by a variety of aquatic macrophytes and smallmouth bass have spawned in the lee of the island. Herring gulls and least sandpipers have nested on the island crest and, in the spring and fall, waterfowl are commonly seen in the sheltered inner bay as they move through on their annual migrations.

Partners: Environment Canada, Ontario Ministry of Natural Resources, Department of Fisheries and Oceans, Ontario Ministry of the Environment, Lake Superior Programs Office, and the Great Lakes 2000 Cleanup Fund.

Contact: Ken Cullis, Ontario Ministry of Natural Resources, Lake Superior Management Unit, (807) 475-1375, ken.cullis@mnr.gov.on.ca

Cost: $595,000 construction, $23,300 assessment

Status: completed

17 Title: Shoreline alteration to restore habitat diversity at a floodway - Thunder Bay, Ontario

Strategy: 11

Objective: Until 1993, the Neebing and McIntyre Rivers entered Lake Superior within one kilometre of each other. Because occasional flooding damaged adjacent residential areas, the narrow, meandering lower portions of the two rivers were filled and replaced with a single straight, wide (~35 m) channel devoid of instream structure. The littoral zone was restricted to a very narrow (<1.5 m) strip along either bank and shoreline and aquatic vegetation was sparse. Upstream portions of both rivers, however, were known for spring and fall rainbow trout spawning runs and resident brook trout populations. Walleye and yellow perch were also present in both river systems. Therefore, this project was designed to create refugia and restore a portion of the original instream habitat diversity in order to benefit both migratory and resident fish populations.

Four embayments (30 m X 2 m) and a collection of wood pilings, log mats, and boulder piles were added to a 1.25 km section of the floodway. The embayment structures were designed to reduce flow rates locally and to diversify littoral habitat in the floodway. Overhead vegetative cover provided shaded resting areas for fish and some degree of protection from predation by birds and mammals. Biological assessment indicated that fish abundance and diversity was greater in the embayment areas than in unaltered sections of the floodway. Habitat enhancement of the Neebing-McIntyre floodway demonstrates the potential for improving aquatic habitat while maintaining the function of flood control within an urban environment.

Partners: Environment Canada, Ontario Ministry of Natural Resources, Department of Fisheries and Oceans, Ontario Ministry of the Environment, Lake Superior Programs Office, and the Great Lakes 2000 Cleanup Fund.

Contact: Ken Cullis, Ontario Ministry of Natural Resources, Lake Superior Management Unit, (807) 475-1375, ken.cullis@mnr.gov.on.ca

Funding: $109,889 construction, $24,200 assessment

Status: Completed

18 Title: Redesign of waterfront park to protect and enhance shoreline - Thunder Bay, Ontario

Strategy: 11

Objective: The City of Thunder Bay has begun the task of revitalizing its waterfront property with the Kaministiquia River Heritage Park. Industrial development and shoreline degradation have left the area devoid of ecological, recreational, and aesthetic value. The Heritage Park was developed to restore the environmental integrity and natural history of the region.

The park was completed in three distinct phases. Phase one included a 25 m wide semi-circular overlook constructed of steel sheet piling and concrete. The soft shoreline was eliminated in this area leaving only a hard straight edge with little cover. In the second phase, a 60 m riverfront promenade was built on steel piles away the river bank thus maintaining the natural shoreline of the area. The boardwalk was extended another 500 m along the shoreline in the final phase of the project. The open pile construction of the boardwalk maximizes the development of aquatic habitat by providing instream cover and enhanced substrate diversity.

The City of Thunder Bay is continuing to work towards a more ecologically productive, aesthetically pleasing, and commercially vital waterfront for the future.

Partners: Great Lakes 2000 Cleanup Fund, Lake Superior Programs Office, Ontario Ministry of Natural Resources, Environment Canada, and the Ontario Ministry of the Environment.

Contact: Ken Cullis, Ontario Ministry of Natural Resources, Lake Superior Management Unit, (807) 475-1375, ken.cullis@mnr.gov.on.ca

Funding: Phase I: $1.3 million, Phase II: $550,000, Phase III: $1.5 million

Status: completed

19 Title: Improving salmonid access to spawning habitat - Thunder Bay, Ontario

Strategy: 11

Objective: The Current River, a Lake Superior tributary stream, has approximately 50 km of potential spawning and nursery habitat available to rainbow trout. Passage of rainbow trout up this river system, however, was blocked by a dam situated approximately 600 m upstream from the mouth of the river.

Access to productive spawning habitat in the Current River was restored in the fall of 1992 with the construction of a fish ladder and step pools at the Boulevard Lake dam. Additional resting pools were excavated below the fishway to expedite upstream passage. A fish transfer program was initiated in 1993 to accelerate the colonization of rainbow trout in the upper reaches of the Current River. It is anticipated that spawning adults, collected from adjacent streams and transplanted to the headwaters of the Current River, will produce a self-sustaining rainbow trout population over time.

Partners: Lakehead Region Conservation Authority, Lake Superior Programs Office, Environment Canada, Ontario Ministry of Natural Resources, Ontario Ministry of the Environment, and the North Shore Steelhead Association.

Contact: Ken Cullis, Ontario Ministry of Natural Resources, Lake Superior Management Unit, (807) 475-1375, ken.cullis@mnr.gov.on.ca

Funding: $407,000

Status: completed

20 Title: Treatment of bacterial contamination at local beach - Thunder Bay, Ontario

Strategy: 12

Objective: The public bathing area at Chippewa Park in Thunder Bay, Ontario, is closed periodically each summer in response to elevated levels of faecal coliform bacteria. Studies at the park have indicated that droppings from Canada geese and seagulls significantly contribute to the problem. Bird droppings, containing extremely high faecal coliform levels, are washed into the bathing area by precipitation events. Drainage from the wildlife exhibit at the Chippewa Zoo flows into a ditch running alongside the beach and enters the bay via the main ditch outfall. Although faecal coliform levels decline with increased distance from the zoo, levels are still high enough to suggest that the zoo ditch contributes to this problem. The situation is exacerbated by a lack of sufficient water circulation in the bay, which limits the ability of the system to flush bacteria from the swimming area.

To date, some improvements have been made to reduce bacterial levels in the Chippewa Beach area. Low-flow fixtures have been installed in the public washrooms, drainage has been improved along the highway and the playing fields, and a new septic system has been constructed to serve the beach and amusement park area.

Partners: Lake Superior Programs Office, Environment Canada, Ontario Ministry of Natural Resources, Ontario Ministry of the Environment, City of Thunder Bay, and the Thunder Bay District Health Unit.

Contact: Ken Cullis, Ontario Ministry of Natural Resources, Lake Superior Management Unit, (807) 475-1375, ken.cullis@mnr.gov.on.ca

Funding: $30,000 (Concept Development and Assessment)

Status: ongoing

21 Title: Enhancing aquatic habitat to bring back walleye ‟ Nipigon, Ontario

Strategy: 11

Objective: Once considered a coarse fish, Nipigon Bay walleye, along with lake sturgeon and northern pike, were deliberately destroyed in the early 1900s ostensibly to protect a failing brook trout fishery. Today, walleye are one of the protected species native to Lake Superior. However, the population is struggling to recover from the effects of overexploitation, pollution, sea lamprey predation, and habitat loss.

In the 1950s, the adult walleye population was estimated to be 41,000 for Nipigon Bay alone. Commercial catches were averaging 8,813 kg annually, but by 1966 the population had collapsed. After two decades of negligible catches (~ 11 kg/year), the commercial fishery for walleye was closed in 1985. Four years later, the walleye sport fishery was also closed. Habitat enhancement and stocking programs were used to restore self-sustaining walleye populations to the Nipigon Bay area. Over 12,000 adult walleye from three different sources were introduced to the system. Since 1993, sampling efforts have revealed evidence of successful reproduction with larval, juvenile, and adult walleye located in this area. Habitat enhancement efforts included the rehabilitation of a wetland adjacent to the mouth of the Nipigon River and the removal of wood debris at walleye spawning sites in the lower Nipigon River.

Partners: Great Lakes 2000 Cleanup Fund, Department of Fisheries and Oceans, Ontario Ministry of Natural Resources, and the Ontario Ministry of the Environment.

Contact: Ken Cullis, Ontario Ministry of Natural Resources, Lake Superior Management Unit, (807) 475-1375, ken.cullis@mnr.gov.on.ca

Funding: $300,000 for stocking program, $100,000 for wetland and spawning habitat enhancement

Status: completed

22 Title: Restoration of Biological Diversity in Forests of Two Great Lakes National Park

Strategy: 8

Objective: Assess current forest structure for comparison with estimated pre-settlement conditions and determining the potential for restoration of pre-settlement conditions.

Results: Part of the project is to assess the use of Canada yew by ground nesting birds and determine the productivity of these bird species.

Partners: Pictured Rocks National Lakeshore, Sleeping Bear National Lakeshore, USGS-BRD Munising Biological Station, Michigan Technological University, Shelter Bay Forests, MI Department of Natural Resources

Contact: Bruce Leutscher, National Park Service, Ph: (906) 387-2607, E-mail: Bruce_ Leutscher@nps.gov

Funding: $363,500 from Natural Resource Preservation Program through National Park Service

Status: start date May 2000

23 Title: Incorporating habitat protection into development plans – Thunder Bay, Ontario

Strategy:

Objective: The Ministry of Natural Resources and an local environmental action group (Thunder Bay 2002) have joined forces to address environmental issues surrounding the development of a new regional health care facility in the City of Thunder Bay. The proposed site borders on the shoreline of the McIntyre River, a tributary to Lake Superior. Both organizations share the view that development in the near shore area can co-exist with the natural environment.

The Thunder Bay Regional Hospital has the potential to set a new standard in ecologically sound development, as the proposed site possesses a wide range of existing natural attributes. The site development plan will provide for the protection of existing streams and wetlands as part of the McIntyre River watershed, protection and potential enhancement of existing aquatic and terrestrial habitat, and proper management of site run-off and snow removal. A landscaping plan that minimizes erosion and/or destruction of natural landscape features, while utilizing and highlighting native plant species will also be included. Suggestions to further minimize environmental impact by maximizing on-site energy and water conservation and waste reduction fixtures and facilities will be considered.

Partners: Ontario Ministry of Natural Resources, Environment Canada, City of Thunder Bay, and Thunder Bay 2002.

Contact: Ken Cullis, Ontario Ministry of Natural Resources, Lake Superior Management Unit. Phone: (807) 475-1375 email: ken.cullis@mnr.gov.on.ca

Funding:

Status: ongoing

Special Designations and Acquisition

24 Title: Keweenaw Threatened, Keweenaw Preserved

Strategy: 5

Objective: Raise awareness of the unique qualities of habitat found on the Keweenaw Peninsula and the importance of preserving these areas.

Results: The Friends of the Land of Keweenaw (FOLK) developed a web site focusing on these areas as a tool to raise public awareness about the threatened sites and aid protection efforts. The web site provides FOLK with a source of easily disseminated information for people who either need an introduction to the issue or want to know more. FOLK also added another location to the web site, Bete Grise, when development was proposed there. Bete Grise is an outstanding example of a Great Lakes Marsh with patterned beach ridge/wetland swale topography. A

subsequent “Lake Superior Shoreline Awareness” event (July 4, 1999) was sponsored by FOLK at Bete Grise and attended by hundreds of people.
Partners: FOLK, Great Lakes Aquatic Habitat Fund

Contact: Linda Rulison, President, FOLK (906) 334-2553, www.portup.com/~folk. The web site, "Keweenaw Threatened, Keweenaw Preserved" is accessible at www.portup.com/~folk/keweenaw

Funding: A grant ($1,800) from the Great Lakes Aquatic Habitat Protection Fund was given to create the web site. FOLK paid an additional $700 to expand the web site and to conduct water quality testing at Bete Grise. Substantial donations were received at a shoreline awareness event.

Status: Ongoing. The web site is complete, but needs periodic updating to stay current.

25 Title: St. Louis River Streambank Protection Area

Strategy: 5

Objective: The objective was to acquire up to 6,823 acres of land to protect the highly erosive red clay watershed of the Red River from further erosion, thereby protecting valuable wetlands bordering the St. Louis River.

Results: Approximately 6,200 acres have been purchased; this is about 91 percent of the 6,823 that were targeted for purchase. This transaction has been well received locally, partly because Wisconsin law specifies payments to local units of government, in lieu of property taxes.

Partners: Wisconsin DNR (WDNR), Douglas Co., City of Superior, St. Louis River Remedial Action Plan, St. Louis River Citizens Action Committee, plus the North American Wetland Conservation Act (NAWCA). The NAWCA grant [“Lake Superior Coastal Wetlands Initiative, Phase 1”] had, as partners: the U.S. Fish and Wildlife Service, WDNR, Ashland-Bayfield-Douglas-Iron Land Conservation Dept., Bad River and Red Cliff Bands of Lake Superior Chippewa, Great Lakes Indian Fisheries and Wildlife Commission, Trout Unlimited, Ducks Unlimited, Audubon Society [Ashland Chapter], and others

Contact: Dale Rochon, WDNR, (715) 399-3100, rochod@dnr.state.wi.us, www.dnr.state.wi.us

Funding: $887,145 ($737,145 from the Wisconsin Stewardship Fund and $150,000 from a NAWCA grant)

Status: Ongoing

26 Title: Park Point Scientific and Natural Area

Strategy:

Objective: To protect a high quality example of Great Lakes Pine forest in the City of Duluth.

Through a donation of land from Superior Water Light and Power, The Minnesota Department of Natural Resources is designating more than 17 acres of Great Lakes Pine forest as a Scientific and Natural Area. The pine forest is a mix of red and white pines established on a stabilized beach dune system. The forest is unusual in that it is comprised of trees of many age classes owing to the harsh conditions and numerous natural disturbances at the site. The site also includes sand beach and fore dune plant communities representative of the Lake Superior Ecosystem, but found only in this location in Minnesota.

Results: Seventeen acres of pine forest and dune habitat were donated by Superior Water Power and Light for designation as a State Scientific and Natural Area. Work is on-going to remove an existing cabin from the area and implement the designation.

Partners: Superior Water Power and Light, Park Point Community Club, Minnesota Land Trust, Minnesota Department of Natural Resources.

Contact: Pat Collins, MN DNR, 1568 Hwy 2, Two Harbors, MN 55616

Funding: A grant from the Legislative Commission on Minnesota Resources to the Park Point Community Club helped facilitate the donation. Other projects costs were borne by the partners.

Status: Donation complete. Designation has been approved by the DNR Commissioner’s Advisory Committee and is in progress.

27 Title: St. Louis River Management Plan and Land Acquisition Project

Strategy:

Objective: To maintain, through management planning and land acquisition, the existing high quality habitat, recreational opportunities and character of the St. Louis river corridor and its two largest tributaries, the Cloquet, and Whiteface rivers .

The rivers flow through a landscape that is largely undeveloped and are bounded for much of their length by aspen and conifer forests. The wild nature of much of the river corridors and the many rapids provide ideal opportunities for canoeing and fishing. Residents and local government officials desired to maintain the character of the river corridors. A Joint Powers Board of local elected officials and a Citizens Advisory Committee worked to develop a St. Louis River Management Plan that implemented, through adoption in local zoning ordinances, management practices to protect the river system. County recreation plans were developed as part of this effort. An important recommendation to arise from the plan was for the State of

Minnesota to acquire riparian land for sale by Minnesota Power Inc. The purpose of the recommendation was to preserve the character of the river and its water quality and habitat.

Results: A St. Louis River Management Plan or "river plan" was developed and aspects of this plan were adopted by local units of government in the affected area. The Minnesota DNR acquired 22,600 acres of riparian land through purchase and donation from Minnesota Power. This includes approximately 150 miles of river frontage on the main stems of the three rivers. A DNR management plan was developed by an "Integrated Resource Management Team" to guide management of the acquired land in accordance with the "river plan". A cooperative project with the Fond du Lac Tribal and Community College established two "Environmental Study Areas" on the river system for research and education.

Partners: St. Louis River Board, local citizens, MN DNR, Legislative Commission on Minnesota Resources, Fond du Lac Tribal and Community College.

Contact, Pat Collins, MN DNR, 1568 Hwy 2, Two Harbors, MN 55616

Funding, The acquired land was worth about $5.5 million. Approximately 20 percent of this value was donated by Minnesota Power. Additional funding to the St. Louis River Board was provided through the MN DNR.

Status. Land Acquisition and management planning is complete. Implementation of plan recommendations including recreation planning and land management actions is on-going.

Watershed Management and Forest Stewardship

28 Title: Miller Creek Restoration

Strategy:

Objective: To sustain the wild brook trout population in the Creek; preserve and restore the ecological functions of the riparian areas through activities such as tree planting, improve the quality and temperature of water entering the stream; support the aesthetic value of the stream and riparian areas; influence planning for future land uses by advising local government on wetland protection and zoning issues.

Miller Creek runs through a highly developed urban area. Highways, an airport and retail development dominate much of the watershed. These sources of stress result in increased stream temperature, higher peak runoff, and increased inputs of salt and sediment (such as sand from winter road maintenance) that degrade habitat for trout and other creatures that live in the cold water system.

Results: Several project have been completed including tree planting, removal of an old bridge that once blocked the stream, public education and involvement of local businesses that own riparian land, clean up of leaking underground storage tanks, and the installation of trout habitat structures. Additional work is on-going and includes the installation of a sediment trap to remove sand from the stream and in-stream habitat improvements.

Partners: Miller Creek Task Force made up of citizens, City of Duluth, City of Hermantown, local sportsman's groups, MN DNR and Minnesota Pollution Control Agency

Contact: Pat Collins, MN DNR, 1568 Hwy 2, Two Harbors, MN 55616.

Funding: Several grants have been recieved through the Clean Water Partnership (MPCA), The Legislative Commission on MN Resources, and others. Thousands of hours of volunteer time has gone into development of the project and implementing restoration actiions.

Status: Ongoing since 1994

29 Title: Chocolay River Watershed Project

Strategy: 25

Objective: Control non-point source pollution and restore degraded habitat important to the Chocolay Watershed (160 sq. miles) in the Lake Superior basin. Over 100 non-point source control projects have been completed including erosion control and storm water management addressing sources such as construction, stream crossings, logging sites and agriculture. The Project has also completed several high profile stream restorations have improved aquatic habitat and have documented dramatic increases in populations of trout and Lake Superior salmon. Restoration efforts have also included two highly publicized dam removals. The project includes an aggressive public education component to prevent future impacts to the watershed.

Results: In 1996, restoration efforts were accomplished on 1.5 miles of Big Creek, a Chocolay River tributary. This involved removal of fallen trees and blocking side channels to allow the original stream channel to reform. Some bank stabilization at stream crossings upstream was done to control sedimentation. As a result of these efforts, the percentage of the substrate that was spawning gravel in the 1.5 miles increased from 3 percent to 46 percent. Some species of trout and salmon nearly doubled in numbers. A dam at K. I. Sawyer Air Force Base was removed restoring flow to the headwaters of another Chocolay tributary, Silver Lead Creek.

Partners: Michigan Department of Environmental Quality, Michigan Department of Natural Resources, U.S. Fish and Wildlife, Trout Unlimited, local townships, Northern Michigan University, Marquette County Conservation District and others.

Contact: Carl Lindquist, 1030 Wright Street, Marquette, MI 49855, Ph: (906) 226-9460, Fax: (906) 228-4484, E-mail: lind@mail.portup.com

Funding: 319 funding, Great Lakes Commission, DNR Fisheries Grant, EPA Coastal Environmental Management Grant and local townships.

Status: ongoing. The Chocolay River Watershed Project was initiated in 1993. Work on this project continues but as part of the Central Lake Superior Watershed Partnership since 1998.

30 Title: Central Lake Superior Watershed Partnership

Strategy: 25

Objective: This unique initiative involves stakeholders from nine Lake Superior watersheds, and is designed to prioritize critical watershed needs and secure funding to complete projects. The Central Lake Superior Watershed Partnership has begun inventory assessments and prioritized non-point source projects. In addition, a comprehensive inventory of critical Lake Superior habitat has begun and will incorporate this information into watershed management plans as well as provide habitat protection information to local planning units and related organizations.

Results: The Central Lake Superior Watershed Partnership provides assistance to a variety of watersheds including: forested, agricultural, urban, and a Great Lakes Area of Concern (AOC) Deer Lake/ Carp River. A priority watershed in the partnership is the Salmon Trout River Watershed which contains the last naturally reproducing population of Coaster Brook Trout (*Salvelinus fontinalis*) on the south shore of Lake Superior.

Partners: Marquette Community Foundation, Northern Michigan University, Central Lake Superior Land Conservancy, local townships, Marquette County, Marquette Conservation District and others.

Contact: Carl Lindquist, Director, 1030 Wright Street, Marquette, MI 49855, Ph: (906) 226-9460, Fax: (906) 228-4484, E-mail: lind@mail.portup.com

Funding: Marquette Community Foundation, Marquette County, local townships, Michigan Department of Envriornmental Quality Coastal Management Grant

Status: ongoing. Formed in 1998, this regional collaborative continues to grow each year. A twenty member advisory council meets monthly. The Central Lake Superior Watershed Partnership is a 501 c 3 non-profit.

31 Title: Torch Lake Remedial Action Plan (RAP)

Strategy: 25

Objective: To achieve the RAP update addressing the 14 beneficial use impairment, support the funding and initiation of currently planned remediation projects, and define the issues and closure requirements of the Torch Lake Watershed in Houghton County, Michigan. The grantee coordinated the efforts of the USDA-Natural Resources Conservation Service in completing the engineering work for the remediation of exposed mine tailings (the sands) along the shore of Torch Lake and adjoining areas of Portage Lake and the Keweenaw Canal.

Results: The grantee completed the initial review and prepared a new draft for the RAP 14 beneficial use impairments. As part of their educational outreach program, a website has been created to provide relevant information about Torch Lake AOC. The grantee participated in the Adopt-a-Stream Program sponsored by the Michigan Technological University about a broad range of educational programs focused on water quality for both teachers of environmental related subjects as well as direct workshops and seminars for students for the benefits and improvement of the Lake Superior Watershed.

Contact: Gary Aho, USDA Natural Resources Conservation Service, (906) 482-1648, gaho@mi.nrcs.usda.gov

Partners: USDA-Natural Resources Conservation Service, Michigan Technological University

Funding: Funded through Coastal Environmental Management funds - $12,000

Status: Phase 1 was completed in 1999. Phases 2-5 will be completed during 2000-04.

32 Title: Whetstone Brook Watershed

Strategy: 25

Objective: Develop a strategy for dealing with sedimentation/water quality problems from construction and stormwater discharge that affect designated cold water fisheries. The Whetstone Brook Watershed Project is approximately 1,400 acres located in the City of Marquette and Marquette Township, Michigan.

In 1990, the Marquette Conservation District formed the Whetstone Brook Watershed Council to deal with these concerns.

Results: Over the last eight years, the council has addressed these concerns through restoration and preventative measures. These measures included installation of two stormwater detention basins, streambank stabilization at several sites, installation of rock chutes, tree planting along streambanks, and annual stream cleanups. Development of a Stormwater Utility & Master Plan has helped the Council utilize local funding mechanisms, build partnerships, and use technology and education as primary methods to implement positive improvements. Public perception of the stream is as a resource instead of a storm sewer.

Partners: City of Marquette, USDI Fish and Wildlife, Marquette Co. Conservation District, Concerned Citizens, WalMart, USDA Forest Service, Northern Michigan University.

Contact: Michael LaPointe, USDA, Natural Resources Conservation Service, (906) 226-9460

Funding: Grant through EPA 319 program that spanned from 1991 through 1996.

Status: Formed in 1991, the Whetstone Brook Watershed Project is continuing through the Central Lake Superior Watershed Partnership. The Whetstone Brook Watershed Council continues to meet on a regular basis and field projects are prioritized and implemented as funding becomes available.

33 Title: Clay Lake Plain Ecosystem

Strategy: 25

Objective: The Michigan Department of Natural Resources Forest Management Division, in agreement with the Upper Peninsula Resources Conservation and Development Council, initiated a USDA forest stewardship project that incorporates non-industrial landowners into ecosystem management at the landscape level. The area selected for the project is the Clay Lake Plain (CLP) of the eastern Upper Peninsula. CLP Ecosystem Advisory Committee has been established to assist in planning and implementing the project. The committee is composed of nineteen members representing landowners, various interest groups and public interests. The advisory committee established the following mission statement for the project, " to promote a cooperative effort to maintain and/or enhance the biodiversity of sustainable ecosystems on private lands in the Eastern upper peninsula through information and education", and identified twelve objectives that should be addressed when planning or applying ecosystem management concepts to lands within the project area.

Results: The most notable result of the project has been the number of individual landowners that have enrolled in the Forest Stewardship Program (FSP) and the extensive number of cost share practices that have been installed on the lands. To date, there are 132 landowners and 23,943 acres enrolled under FSP. That represents 7 percent of the non-industrial private acres within the CLP. The project has been successful in reaching the larger acreage class, average acres of ownership is at 181 acres. Although this ownership class has shown that they are most likely to follow up on their stewardship plan and install practices, we have not attracted those smaller ownerships. The project has been successful in reaching the larger acreage class with properties between 20 and 1,620 acres. The average acreage ownership is at 181 acres. This ownership class has been found to be most likely to follow up on their stewardship plan and implement the conservation practices. We have not attracted smaller ownerships.

Partners: Upper Peninsula Resource Conservation & Development Council, Michigan Department of Natural Resources, USDA, Chippewa Soil Conservation District.

Contact: DeVillez, Michigan Dept. of Natural Resources, (906) 293-5131, deviller@state.mi.us; or Seldon Collins, USDA, Natural Resource Conservation Service, (906) 632-9611 ext 3, scollins@mi.nrcs.usda.gov

Funding: supported in part by a grant from the Michigan Department of Natural Resources, USDA Forest Service and the State Forest Stewardship Committee.

Status: Ongoing

34 Title: Knife River Watershed Forest Stewardship Project

Strategy: 25

Objective: To educate landowners and the public regarding ways to minimize and prevent soil erosion and sedimentation, and how to protect water quality and wildlife and fish habitat in the Knife River and Lake Superior Watersheds.

Results: This stewardship project produced ten "Edge of the Knife" newsletters to educate over 650 landowners and interested persons about good conservation practices to conserve soil and water resources (the Knife River Watershed encompasses 55,000 acres of private and public land). The project completed Forest Stewardship Plans for 79 landowners and encompassing 6,077 acres of land (70 percent of the private land base in the watershed); sponsored cost-share programs that include tree planting, riparian forest buffer establishment, flood control structures, and pasture management practices; distributed fact sheets to educate landowners and the public about the watershed; and produced and placed education signs in the watershed to educate the landowners and the public about the watershed and good conservation practices. In addition, three successful public meetings were held and one tour of the Knife River Watershed for landowners and interested persons was conducted. A compilation of a Geographic Information System database that encompasses information from several county and state agencies and departments was compiled. Currently, a bio-engineering demonstration project is being prepared to be conducted in Spring 2000 using volunteer labor, with the goal of educating landowners and others in methods they can use to prevent or decrease soil erosion on their property.

Partners: Laurentian Resource Conservation & Development (RC&D) Council, Inc., USDA Natural Resources Conservation Service (Natural Resources Conservation Service), Minnesota Department of Natural Resources (DNR), Lake County Soil and Water Conservation District (SWCD), St. Louis County SWCD, Lake Superior Steelhead Association (LSSA), Board of Water and Soil Resources (BWSR), U.S. Environmental Protection Agency (U.S. EPA), Potlatch Company, and Interested Landowners.

Contact: Laurentian RC&D Council, Inc., 4850 Miller Trunk Highway, Ste 3B, Duluth, MN 55811, phone - 218-720-5225 fax - 218-720-3129, kim.samuelson@mn.usda.gov, www.mn.nrcs.usda.gov/rcd/laurentian/

Funding: Great Lakes Basin Program for Soil Erosion and Sediment Control (Grant) 1999-2000 $10,230.00, Education Grant Program for EQIP in Minnesota: USDA Environmental Quality Incentives Program (Grant)1998-1999 $8,550.00, Great Lakes Basin Program for Soil Erosion and Sediment Control (Grant)1996-1998 $10,415.00, Lake Superior Steelhead Association (match for grant)1996 $6,500.00, Lake Superior Steelhead Association (donation for tree-cost share) 1999-2000 $1,500.

Status Ongoing since 1992. The Knife River Stewardship Committee (comprised of representatives from the listed partners) has been meeting at least six times a year and is very active in working with, and educating, landowners to implement Best Management Practices in the watershed. The project will continue as long as funding is available.

35 Title: Northern Rivers Initiative

Strategy: 25

Objective: A prioritized list of stream corridors will be developed in the 20 northern-most Wisconsin counties that warrant additional protection against the pressures that threaten them, based on their high ecological significance, outstanding natural scenic beauty, and exceptional recreational opportunities. A wide range of options to provide additional protection to high-quality streams would be made available.

Results: Participants reviewed the existing alternatives for protecting rivers and stream shorelands. The range of options includes education, voluntary conservation through landowner stewardship, financial incentives, technical assistance to local decision makers, and public acquisition.

Partners: The current mailing list for the Northern Rivers Initiative includes approximately 240 interested groups and individuals, representing federal, state, tribal and local units of government, industry, landowners, educators and conservation organizations.

Contact: Wisconsin Department of Natural Resources, P.O. Box 220, Park Falls, WI 54552. Answers to FAQs about the Northern Rivers Initiative are currently posted on the Department's web site (www.dnr.state.wi.us)

Funding: In FY 2000, the Northern Rivers Initiative received $11,500 of General Program Revenue funding from the Department's Watershed Program. In addition, the Department's Lands Program in the Upper Chippewa River Basin provide cooperative support for implementation of stream protection, i.e. landowner contacts, educational presentations, etc. Production, duplication, and distribution of the videotape were jointly funded by the Ashland and Bayfield County Land and Water Conservation Department, the Minnesota Arrowhead Water Quality Group, the St. Croix Basin Partners Team, Wisconsin's Northern Initiatives, Parthe Productions, and a grant from the Wisconsin Environmental Education Board.

Status: A preliminary draft for the prioritized list of streams and an educational videotape on river protection should be completed in 2000. Participants will meet in 2000 to decide how to reorganize the subcommittees and carry out specific recommendations for stream protection.

36 Title: Two-Hearted River Watershed Landscape Management Project

Strategy: 25

Objective: The Two-Hearted River watershed is located in northern Luce County in the Upper Peninsula and is identified as an Important Habitat Area due to the extensive area of undisturbed wetland complexes. The river itself is also designated by the State of Michigan as a Natural

River. Using the example of similar successful land conservancy plans, this project has the goal of developing a strategy for identifying ecological units within a landscape, defining appropriate management activities within an ecological unit, and targeting of non-industrial private landowners withing the project area in order to: inform and educate landowners to the concept, the progress, and the success of landscape management. Additional goals include: increasing public awareness and support for landscape strategies and the right to voluntarily participate in any plans to manage those landscapes; providing landowner with information on voluntary technical and incentive-driven programs to accomplish landscape management; gathering and sharing broad-based inventories; researching data; and demonstrating and applying landscape management concepts with the landowner. The U.P. Resource Conservation and Development Council has been working to disseminate information on the project to the landowners in the Two-Hearted River watershed.

Partners: The Luce-West Mackinac Conservation District, the Michigan Department of Natural Resources, the Michigan Natural Resources Forest Stewardship Program, The Eastern Upper Peninsula Partners in Ecosystem management, and the Upper Peninsula Resource Conservation & Development Endowment Fund.

Funding: $12,500

37 Title: Shoreline Management Plan for Lake Superior

Strategy: 25

Objective: The shoreline management plan for the Lake superior waters of the Sault Ste. Marie District was completed in the late 1980s. The database for the plan involved extensive surveys of the gross physical shoreline structures, including video taping the entire shoreline by helicopter. Detailed maps of the shoreline are kept at the Sault St. Marie District Office. The plan involved public participation through open-houses for the collection of information, as well as developing planning options The shoreline from Sault Ste. Marie to Lake Superior Provincial Park was divided into reaches for specific management prescriptions.

The shoreline management plan for south-eastern Lake Superior was designed to: facilitate the orderly development and conservation of Ontario"s land and water resources for continuous social and economic benefits of Ontario, prevent loss of life, and minimize social disruption, property damage and loss of natural resource values from floods erosion and earth slippage; and, minimize the detrimental effects of development, and preserve and enhance the natural functions of sensitive shore ecosystems.

Results: Implementation of the plan resulted in an improved coastal environment and understanding of its associated elements, including; shore processes, such as sediment transport and erosion, the natural environment, including wetland areas and associated plants, fish and wildlife, fluctuations in water levels; and, the social, aesthetic, and related land and water uses of this area.

Contact:

Funding: $40,000

38 Title: Nemadji River Watershed Project

Strategy: 11

Objective: To form federal, state, and local partnerships to reduce erosion and sedimentation impacts to the Duluth Superior Harbor and Lake Superior.

Results: Forest harvest management planning process begun on a watershed scale. U.S. Army Corp. of Engineers sediment model under development, Forest Stewardship and Conservation plans and practices applied. Watershed Geographic Information System developed.

Status: Ongoing

Contact: Joanne Rosberg, University of MN Extension, P O Box 307, Carlton MN 55718- 0307 (218) 384-3511, jrosberg@extension.umn.edu

Funding: USDA EQIP, EPA 319, Minnesota Clean Water Partnership, Minnesota Department of Natural Resources Forest Stewardship Program, U.S. Army Corps of Engineers, Carlton County

Partners: Carlton County Soil and Water Conservation District, Carlton County Minnesota, Douglas County Wisconsin, Minnesota Department of Natural Resources, Minnesota Pollution Control Agency, Minnesota BOWSR, Saint Louis River Citizen Action Committee, Metropolitan Interstate Committee, U.S. Army Corps of Engineers, Natural Resources Conservation Service, U.S. Forest Service, U.S. Environmental Protection Agency

39 Title: Midway River Watershed Project

Strategy: 11

Objective: Reduce sediment and nutrient loading to the Midway River, Thompson Reservoir, and the St. Louis River.

Results: Developed an organization to direct efforts. Prepared application for funding received through Minnesota Pollution Control Agency 319 program.

Status: Beginning

Contact: R. C. Boheim, District Manager, South Saint Louis Soil and Water Conservation District, 4850 Miller Trunk Hwy, Suite 2-B, Duluth MN 55811, (218) 723-4867, rboheim@mn.usda.gov

Funding: Minnesota Pollution Control Agency 319 NPS Program

Partners: South St. Louis County Soil and Water Conservation District, Esko School District, Minnesota Department of Natural Resources, Minnesota Pollution Control Agency, Minnesota Board of Water and Soil Resources, Natural Resources Conservation Service, Minnesota Power, DM&IR Railroad, Isaak Walton League, Trout Unlimited

40 Title: Sucker/French/Talmadge/Lester Watershed Forest Stewardship Project

Stragegy: 25

Objective: Federal, state, and local partnership effort to use soil and water conservation practices that will reduce flooding and erosion to improve water quality and fish habitat.

Results: Developed an organization to direct efforts. Prepared application for funding received through Minnesota Department of Natural Resources Forest Stewardship Program.

Status: Beginning

Contact: R. C. Boheim, District Manager, South Saint Louis Soil and Water Conservation District, 4850 Miller Trunk Hwy, Suite 2-B, Duluth MN 55811, (218) 723-4867, rboheim@mn.usda.gov

Funding: Minnesota Department of Natural Resources Forest Stewardship Program

Partners: South Saint Louis County Soil and Water Conservation District, Minnesota Department of Natural Resources, Minnesota Board of Water and Soil Resources, Natural Resources Conservation Service

41 Title: Skunk Creek Watershed Project

Strategy: 25

Objective: Control flooding and erosion resulting from storm water runoff generated by increasing development in the watershed which encompasses part of the City of Two Harbors. Skunk Creek discharges into Lake Superior within one-quarter mile of the municipal water supply intake.

Results: A local citizens group has organized and led the effort to date resulting in the completion of a land use inventory, stream clean-up efforts completed and a community trail system developed along the creek. A storm water management plan is currently being developed by the City of Two Harbors.

Partners: Lake County, City of Two Harbors, Lake County SWCD, Lake County Water Plan, Skunk Creek Citizens Group

Contact: Wayne Seidel, Conservation Specialist, Lake SWCD, P.O. Box #14, 601 Third Avenue, Two Harbors, MN 55616, (218) 834-8370, Wseidel@extension.umn.edu

Funding: City of Two Harbors and Lake County

Status: This is an active ongoing project.

42 Title: Grand Marais Watershed

Strategy: 25

Objective: Federal, State and local partnership effort to reduce flooding and erosion to protect property and improve water quality in Lake Superior.

Results: Developed an organization to coordinate efforts, prepared and submitted an application for a Great Lakes Commission Erosion and Sediment Control grant.

Partners: Cook Soil and Water Conservation District, Cook County, City of Grand Marais, Minnesota Board of Water and Soil Resources, Natural Resources Conservation Service

Contact: Rebecca Wiinanen, Cook County Soil and Water Conservation District, Box 1150, Grand Marais, MN 55604, (218) 387-3000 x147, rebecca.wiinanen@co.cook.mn.us

Funding: None at this time - application to Great Lake Commission pending

Status: Beginning

43 Title: Flute Reed River Watershed Forest Stewardship Project

Strategy: 25

Objective: Federal, State and Local partnership effort to use soil and water conservation practices that will reduce flooding and erosion to improve water quality and fish habitat.

Results: over 2,000 acres of Forest Stewardship plans have been completed on private land.

Partners: Cook County Soil and Water Conservation District, Cook County, Minnesota Department of Natural Resources, Minnesota Board of Water and Soil Resources, Natural Resources Conservation Service, Laurentian Resource Conservation & Development, Lake Superior Steelhead Association

Contact: Rebecca Wiinanen, Cook County Soil and Water Conservation District, Box 1150, Grand Marais MN 55604, (218) 387-3000 x147, rebecca.wiinanen@co.cook.mn.us

Funding: Minnesota Department of Natural Resources Forest Stewardship Program, Lake Superior Steelhead Association

Status: Ongoing

44 Title: Miller Creek Watershed Project

Strategy: 25

Objective: Restore and protect an urbanized trout stream sustaining a wild population of brook trout.

Results: Forest riparian buffer establishment through tree planting, annual volunteer stream clean up, watershed diagnostic study completed, water quality model completed. Watershed Geographic Information System developed.

Partners: City of Duluth, City of Hermantown, Isaak Walton League, Trout Unlimited, Together Reach Out and Upgrade Trout, South St. Louis Soil and Water Conservation District, Minnesota Pollution Control Agency, Minnesota Board of Water and Soil Resources, Natural Resources Research Institute, Lake Superior College, Hermantown High School, U.S. Air Force National Guard, Natural Resources Conservation Service, Saint Louis River Citizens Action Committee

Contact: R. C. Boheim, District Manager, South Saint Louis Soil and Water Conservation District, 4850 Miller Trunk Hwy, Suite 2-B, Duluth MN 55811, (218) 723-4867, rboheim@mn.usda.gov

Funding: Minnesota Pollution Control Agency Clean Water Partnership, EPA 319 NPS Program, Watershed Guardian program,
MN LCMR

Status: Ongoing

45 Title: Development of a Water Management Plan " Nipigon, Ontario

Objective: The Nipigon River flows southward from Lake Nipigon, through Lake Helen, and discharges into the northwestern portion of Nipigon Bay on Lake Superior. The river is the largest Lake Superior tributary, with a mean annual flow of 365.3 m^3/s.

Hydroelectric development downstream of Lake Nipigon consists of the Pine Portage, Cameron Falls, and Alexander Generating Stations, producing 275 megawatts of power under maximum flow conditions. Alteration of flows, particularly dramatic daily fluctuations, led to widespread problems in the system. Owners of shoreline lands on Lake Nipigon and the Nipigon River suffered property damage and boaters in the system complained of adverse conditions. The lake and river fishery was also affected by unnatural water level fluctuations. Brook trout redds were found high and dry in the winter and the groundwater supply, crucial to embryo survival, was being affected. In the interim, the Ministry of Natural Resources developed an agreement with Ontario Hydro to maintain a minimum flow in the Nipigon River, when possible, of 270 m^3/s or greater from October to May and 170 m^3/s or greater for the remainder of the year. A longer term solution, however, was needed.

The Nipigon River Management Committee was formed in 1990 in response to increasing recreational, industrial, and commercial demands being placed on the Nipigon River watershed and to deal with conflicts among water resource users. Their overall goal was to establish, through public involvement, a management option that would reduce the impacts Ontario Hydro‟s hydroelectric dams have on the Lake Nipigon/ Nipigon River watershed, particularly the Nipigon River fishery. An optimization computer model, which employed historical water level and flow data, was used to develop a range of management options. The preferred option considers the target level or flow desired by each stakeholder, given appropriate weighting factors, and determines the Lake Nipigon water level and Nipigon River flow that best suits everyone collectively throughout the year. Controlling water level fluctuations should significantly improve conditions for brook trout in the lower river while making a marginal difference in the value of hydroelectric power generated.

Partners: Great Lakes 2000 Cleanup Fund, Environment Canada, Department of Fisheries and Oceans, Ontario Hydro, Ontario Ministry of Natural Resources, Nipigon Bay Remedial Action Plan, and the Ontario Ministry of the Environment.

Contact:

Funding: $400,000

Status: completed

46 Title: Watershed Management Plans -Thunder Bay and Sault Ste. Marie, Ontario

Strategy: 25

Objective: Watershed management that addresses urban, rural, and industrial development is a proactive approach to the application of pollution prevention concepts in Lake Superior. Habitat degradation caused by water management practices along rivers and streams is a significant problem in each of the Great Lakes Areas of Concern (AOC). Pilot watershed management plans have been developed in two Remedial Action Plan areas: the Slate River in Thunder Bay and the Bennett-Davignon River system in Sault Ste. Marie, Ontario. These watersheds best reflect stresses common to Northern Ontario AOCs.

The Slate River Watershed Management Plan addresses physical degradation and aesthetic impairment associated with agricultural practices in this area. Nutrient enrichment and erosion have resulted in the physical degradation of benthic habitat downstream in the Kaministiquia River. The plan recommends improved water management practices in order to reduce the impact of organic enrichment, turbidity, and sedimentation on the stability of benthic habitat and levels of productivity in this portion of the AOC.

The Bennett-Davignon River system has its headwaters to the north of Sault Ste. Marie atop a largely undisturbed area of Precambrian Shield. Both streams flow over the edge of the Shield and into the municipality of Sault Ste. Marie where they flow through the main groundwater recharge and aggregate extraction zone for the city. They continue southward through rural residential and agricultural lands before entering an urban residential area. From here, the stream courses have been altered and combined such that they flow through active industrial land (Algoma Steel Inc.) and discharge into the St. Marys River at the Algoma Steel boat slip.

The Bennett-Davignon Watershed Management Plan identifies the range of disturbances present within this system and recommends possible mechanisms for the protection of remaining environmental values. The plan outlines specific remedial options to rehabilitate aquatic and terrestrial habitat, reduce erosion, improve aesthetic and recreational opportunities, enhance water quality within the streams and subsequently, the St. Marys River, and to protect streamside property values.

Partners: Great Lakes 2000 Cleanup Fund, Lake Superior Programs Office, Environment Canada, Ontario Ministry of Natural Resources, Ontario Ministry of the Environment, and the Department of Fisheries and Oceans.

Contact:

Funding: $120,000 for each plan

Status: completed

47 Title: Minnesota Point Protection Project

Strategy: 25

Objective: Protect a unique ecosystem, including a 45 acre stand of old growth white and red pine forest, a bird sanctuary, beach dunes and other habitats from partial destruction by the Duluth Airport Authority, as authorized by the City of Duluth (Ordinance 9215). This objective will be met by establishing permanent conservation easements, development of a binding management plan that will provide a level of protection sufficient to ensure the continued ecological integrity of the area and to prohibit further cutting of the old growth forest area. Furthermore, the management plan and communications products will document the value of this unique habitat in a scientific manner for decision-makers at municipal and state levels of government and informing the general public regarding this state treasure. (Statement from the Work Program)

Results: Planted 6,000 culms of American Beach grass, 3,000 trees and shrubs, and fenced off 2 square blocks of severely eroded dunes. Placed 24.6 acres of unique habitat into protected status. Developed an Environmental Management Plan for Minnesota Point. Established a web site for dissemination of information including the Management Plan.

Partners: The Park Point Community Club, Minnesota Department of Natural Resources, City of Duluth, Minnesota Land Trust, Duluth Airport Authority, and the U.S. Army Corps of Engineers.

Contact: Project Manager; Kinnan Stauber 4139 Lake Ave S., Duluth MN 55802, 218/722-6255, kkstauber@aol.com. Website: www.parkpoint.org

Funding: Biennial Project Budget $75,000

Status of the project:
Completed June 31, 1999

48 Title: Lake Superior Decision Support Project

Strategy: 3

Objective: The Project is an effort to develop Geographic Information System (GIS) based decision support applications focused on the Lake Superior Basin. These applications are designed for use by a wide audience, including local governments, regional planning agencies, resource management groups, educational and interpretive organizations, advocacy groups, and individual citizens. The primary goal of the project is to provide users with practical tools they can apply to local land and resource decisions in a context of basin-wide objectives for long-term sustainability and stewardship. The second goal is to provide tools to interpretive and educational institutions to foster public awareness and support of Geographic Information System-based land use decision support. Together, the Geographic Information System applications and databases will provide for analysis, assessment and policy development at local and regional scales simultaneous consideration of ecological, economic, resource and other phenomena prediction of future conditions, based on computer models and extrapolation of current trends. This last capability will be key in focusing efforts on critical locales and situations where the decision support mechanisms developed in this project can be most effectively applied.

Results: Data and maps have been developed and are available from the Internet at: HTTP://oden.nrri.umn.edu/lsgis/

Partners: Lake Superior Binational Program, Lake Superior Ecosystem Cooperative, Minnesota Department of Natural Resources, Natural Resources Research Institute, and Michael Koutnik

Contact: Pat Collins, MnDNR, 218-834-6612, patcollins@dnr.state.mn.us

Funding: Project funding has been provided by U.S. Environmental Protection Agency‟s Coastal Environmental Management fund, Minnesota Department of Natural Resources and The University of Minnesota‟s Natural Resources Research Institute.

Status: Ongoing. Phase 1 is scheduled for completion in October, 2000.

49 Title: Goulais River Watershed Project

Strategy: 25

Objective: Launched in 1999, this is a two year project focused on converging different views on what makes the area and its resources valuable and how the areas beauty can be protected and used to develop greater prosperity for the local area. Activities will include developing a watershed map, campsite and trail clean-up, promotional materials community meetings to encourage watershed stewardship and tours of important habitats and resources of the watershed.

Results:

Contact: Goulais River Watershed Project, 736A Queen St. E., Sault Ste. Marie, ON, P6A 2A9

Partners:

Funding:

Status: Ongoing

Monitoring, Assessment and Inventory

50 Title: Michigan Upper Peninsula Coastal Wetland Project

Strategy: 14

Objective: This is a multi-phase landscape scale project to protect, restore, and manage coastal wetlands and associated uplands in the Lake Superior and St.Mary=s River watersheds in Michigan. The partnership anticipates three additional phases. This Phase I proposal includes 9 focus areas throughout the project area. The peninsula has not seen the same great wetland losses as lower Michigan, with the exception of the Rudyard Clay Plain. For this reason, this project focuses on preventing destruction of coastal wetland areas and associated uplands with habitat restoration/enhancement as a secondary objective. The best way to ensure perpetual protection is through fee title or easement acquisition of these properties by government agencies and conservation organizations. Activities conducted during the performance period will preserve 1,237 acres of wetlands and 1,573 acres of associated uplands. Seven thousand eight hundred forty-seven feet of Lake Superior shoreline will be protected from development, 3,347 feet of which is identified as Aessential breeding habitat@ in the draft Piping Plover Recovery Plan.

Results: To date 135 acres have been purchased on the Whitefish peninsula.

Contact: David Brakhage,Waterfowl Biologist, Ducks Unlimited, 331 Metty Drive, Ann Arbor, MI, 48103, 734-623-2000, fax 734-623-2035,dbrakhage@ducks.org

Partners: Ducks Unlimited, Michigan Department of Natural Resources, Keweenaw Bay Indian Community, Bay Mills Indian Community, Great Lakes Indian Fish & Wildlife Commission, The Nature Conservancy, Whitefish Point Bird Observatory, Village of L=Anse, U.S. Forest Service - Ottawa National Forest, Natural Resources Conservation Service, U.S. Fish and Wildlife Service, private landowners, Upper Peninsula Resource, Conservation & Development

Funding: $2.7 million in partner funds and $1 million in funds from a North American Wetland Conservation Act grant

Status: Performance period ends in September 2002.

51 Title: Fish Habitat Mapping Project in Whitefish Bay - Eastern Upper Peninsula

Strategy: 2

Objective: Whitefish Bay supports an important fishery in the eastern part of Lake Superior. In addition to whitefish, indigenous species like the emerald shiner, the spottail shiner, the white sucker, and the yellow perch spawn in the different habitats encompassing Whitefish Bay. Little has been known regarding the distribution of lifestages of the fish in Whitefish Bay in relation to the different habitats of the lake bed. Understanding the spatial distribution of habitat types and their use by different life stages of whitefish and other indigenous fish species is a requisite for protecting the habitat.

In 1998-1999, the Ashland Biological Station of the United States Geological Service-Biological Resources Division (USGS-BRD) in partnership with the Chippewa-Ottawa Treaty Fishery Management Authority (COTFMA), used sonar technology to map the substrate of the bay and then combined biological information to form a Geographic Information System data base. The electronic mapping of bottom substrates involved integrating the echo from the depth sounder with a sea bed classification sensor and a differential Global Positioning System (GPS) along a transect that was run perpendicular to shore. A RoxAnn sea bed sensor was used to interpret the signals from the echo sounder as smooth or rough and hard or soft. Ponar dredge samples and a video camera were then used to ground truth the values recorded by the RoxAnn. Biological data on fish species, age and reproductive information was collected using seines and trawls during the same time period as the geographical mapping was taking place.

Results: The final product will be an accessible tool for resource managers and environmental decision makers in the Great Lakes in order to protect or enhance the fisheries resources.

Partners: Ashland Biological Station of the USGS-BRD, Chippewa-Ottawa Treaty Fishery Management Authority and the U.S. Environmental Protection Agency, Region V Water Division.

Funding: $82,800

Status: Completed

52 Title: Quantification and Distribution of Bottom Substrates and Fish Utilization in Tahquamenon Bay, Lake Superior

Strategy: 2

Objective: The objective is to gather information that can be used to both identify critical habitats for Lake Superior fishes, and to protect the critical habitat from development or destruction. This is achieved by 1), describing the spatial distribution and quantity of various bottom substrates from the interface of the shoreline with the water to depths of 10m; 2) describing the spatial distribution and abundance of different life stages of several fish species in relation to the various bottom substrates; and 3) identifying bottom substrates that are critical for reproduction and survival of several fish species.

Results: Mapping of the bottom substrates and sampling fish populations in lower Whitefish Bay from the mouth of the Tahquamenon River to Cedar Point has been done. Most of the bottom substrates are either hard sand or cobble and rubble. Little bedrock exists in the entire area. Spatial distributions and abundance of larval lake whitefish have been defined in relation to the bottom substrates. Larval whitefish are found almost solely in shallow, flat, open, sandy areas in lower Whitefish Bay. Larval whitefish are found most commonly in southern Whitefish Bay and the upper St. Mary‟s River in the shallow sandy areas. The most common species caught in beach seines were spottail shiners, lake whitefish, and sand shiners. The common species caught in bottom trawls were johnny darters and scuplins in the open, sandy bottomed, deeper areas of Whitefish Bay in waters less than 60 ft. In the rocky deeper areas sculpins and crayfish were the most commonly captured species.

Partners: U.S. EPA, Chippewa/Ottawa Treaty Fishery Management Authority, USGS Biological Resources Division, USFWS Sea Lamprey Control Center

Contacts: Mike Ripley or Mark Ebener, Inter-Tribal Fisheries & Assessment Program, 179 W. Three Mile Road, Sault Ste.Marie, MI 49783, Ph: (906) 632-0072 or 0073, Fax: (906) 632-1141, E-mail: Mark Ebener - mebener@northernway.net or Mike Ripley - mripley@northernway.net

Funding: $38,000 - $46,000 annually from U.S. EPA

Status: Completed sampling of bottom substrates in lower Whitefish Bay. Completed sampling fish populations in lower Whitefish Bay. Have not finished creating maps. Will begin mapping substrates and sampling fish populations in northern Lake Huron in 2000.

53 Title: Mapping Lake Trout Spawning Habitat Along the North Shore of Lake Superior

Strategy: 2

Objective: To map substrate used by lake trout for spawning activity along the Minnesota shoreline. To produce a Geographical Information System (GIS) based atlas with location and substrate type depicted from 3-30 m in depth parallel to the shoreline.

Results: The atlas and report have been produced and used by decision makers when determining potential consequences of their decisions. Also it has been used to prioritize funding for a variety of projects (erosion control, septic assistance, shoreline development, etc.). Available as Natural Resources Research Institute Technical Report No. Natural Resources Research Institute/TR-99-01

Partners: Minnesota Department of Natural Resources, Natural Resources Research Institute - University of MN, USGS-Ashland Field Station

Contacts: Don Schreiner, MNDNR Lake Superior Fisheries, 5351 North Shore Drive, Duluth, MN 55804 (218) 723-4785 email - don.schreiner@dnr.state.mn.us; Carl Richards, Natural Resources Research Institute, 5013 Miller Trunk Hwy., Duluth, MN 55811; See Natural Resources Research Institute web-site.

Funding: $250,000 from LTV Steel through the Minnesota Pollution Control Agency

Status: Completed February 1999

54 Title: Duluth Area Natural Resources Inventory

Strategy: 1

Objective: The City and surrounding area has an abundance of undeveloped space consisting of a variety of natural environments ranging from steep hillsides with bedrock outcroppings to a myriad of stream courses, tree stands some of which are old growth or near old growth as well as wetlands. Such areas support a whole host of wildlife in these habitats not common in similar sized cities elsewhere in the country.

In recent years, a number of development projects have become very contentious over the impact on natural conditions. There is no reason to believe this situation will change in the foreseeable future. Such struggles occur in the absence of reliable commonly accepted environmental data that can be used as the clear basis for decision-making and are most often settled strictly on a political basis or referendum.

The development of a Comprehensive Plan for the city will depend heavily on the base data provided by such an inventory. The objective is to define sensitive areas to be retained in their natural state for protection from future development or significant alteration. It will also identify areas where it may be possible to develop with certain precautions without harming the more fragile environmental portions and areas where significant protection beyond the normal attention is not necessary. A rating system for each natural resource is one of the goals to be used as a tool.

Results: The first phase of the project, compilation of existing data and an analysis of the adequacy of the information and its capability of being converted to a Geographical Information System, has recently gotten underway. To date the effort to develop the natural resources inventory, initiated by the City Environmental Advisory Council, has not encountered any opposition. To the contrary, a great deal of moral support has been received to the effect that "this only makes sense when trying to determine impacts of development on Greenfield sites".

Partners: Local Audubon Society Chapter, the City Tree Commission, the Minnesota Department of Natural Resources, Minnesota Pollution Control Agency, the University of Minnesota's Natural Resources Research Institute and the Sustainable Development Partnership, the Park Point Community Club, City of Duluth Stormwater Utility, the City Planning Office, the Public Works Department, the Western Lake Superior Sanitary District, The Nature

Conservancy, the Natural Resources Conservation Service, several members of the EAC and citizens from various walks of life with environmental interests. Additional representation from other elements of the community will soon be invited to join those already involved such as the Chamber of Commerce, development groups and the Building Trades.

Contact: William C. Majewski, Business Developer, City Planning Division, 409 City Hall, Duluth, MN 55802, (218) 723-3328 FAX 218-723-3400, E-mail - bmajewski@ci.duluth.mn.us

Funding: Total cost = $200,000. $7,300 from the Minnesota Department of Natural Resources Conservation Partnership Program. $2,000 from the City of Duluth.

Status: Ongoing

55 Title: Habitat Plan for the Lower St. Louis River

Strategy: 8

Objective: Develop a comprehensive AOC wide plan for habitat protection and restoration that includes both general zones of shared ecological management objectives and specific habitat projects.

Results: Geographic Information System maps have been developed and contractors have met with local land managers.

Partners: St. Louis River Citizens Action Committee, U.S. Environmental Protection Agency (U.S. EPA), Minnesota Department of Natural Resources (MN DNR), Wisconsin Department of Natural Resources, The Nature Conservancy, U.S. Fish and Wildlife Service, City of Duluth, U.S. Coast Guard, and others.

Contact: Karen Plass, St. Louis River Citizens Action Committee, 218-733-9520, slrcac@stlouisriver.org, www.stlouisriver.org

Funding level: $59,711 ($49,711 from EPA, plus $10,000 from MN DNR). In addition, $7,000 has been requested from The Nature Conservancy.

Status of the project: Projected completion date of May 2001

56 Title: Shoreline Habitat Survey

Strategy: 2

Objective: Habitat modification in the near-shore (<1 m water depth) zone of Batchawana Bay, Lake Superior, has occurred through the removal of emergent aquatic vegetation for the purpose of creating "clean" beach areas, and secondly, through the removal of cobble and rubble to create groynes for boat protection and possible beach creation. The purpose of this study was to quantify the impact that removals of aquatic vegetation and cobble have on fish in Batchawana Bay. Inferences from this study could be used to facilitate shoreline management planning as well as assist in the prosecution of those guilty of destroying fish habitat. A survey was conducted in the summers of 1994 and 1995 to compare species composition and abundance between disturbed and undisturbed habitat. In the 1994 survey, two types of habitat were examined: vegetated sites and cobble sites, with two disturbance categories (disturbed, undisturbed).

The 1995 survey on vegetated sites (55 electrofishing pairs, 45 fyke net pairs) indicated significantly lower fish abundance on the disturbed sites: The losses were distributed over most species, including fish of recreational value such as yellow perch and smallmouth bass. Many of the disturbed cobble sites appeared to have been subjected to a superficial rearrangement of material. A future experiment should be conducted on sites of extreme disturbance in which the substrate has been scraped down to sand or gravel.

The results of the survey were embraced by the Batchawana Bay Working Group, and a pamphlet on the importance of shoreline habitat was distributed throughout the community with the assistance of the working group partner.

Contact:

Funding: $7000

Partners: Batchawana Bay Working Group, Ontario Ministry of Natural Resources
Status: completed

57 Title: Marsh Monitoring Program

Strategy: 1

Objective: Through the efforts of hundreds of volunteers throughout the Great Lakes region, the Marsh Monitoring Program (MMP) provides information on the population trends and habitat associations of marsh-dependant amphibians and birds. This information makes an important contribution to the conservation and management of Great Lakes basin wetlands and their wildlife.

Results: By communicating the results of standardized, volunteer-based, and geographically extensive surveys, the Marsh Monitoring Program makes a unique contribution to the stewardship, management, and understanding of Great Lakes wetland amphibians, birds and habitats. The contributions and achievements of the MMP include; assessment of amphibian and marsh bird abundance and diversity in Great Lakes basin wetlands, status of prominent marsh-dependent communities, especially in Great Lakes Areas of Concern, scientifically rigorous surveys and analysis methods for volunteer-based marsh species monitoring and habitat assessment, important habitats and potential management directions are being identified for species of conservation concern, a long-term, geographically extensive set of data, essential to measuring wetland and species' responses to management approaches and natural events (e.g. water level control, climate change), and building the capacity and concern of the region's citizens for conservation science.

Information gained through MMP surveys is conveyed to the region's citizens through public presentations, interviews and articles in newspapers, newsletters and magazines. Results are also provided to governments, wetland managers, and the wetland restoration and scientific communities through reports, presentations and papers in the scientific literature.

Partners: The MMP is delivered by Bird Studies Canada (formerly Long Point Bird Observatory) in partnership with Environment Canada and with support from the U.S. Environmental Protection Agency, Great Lakes Protection Fund.

Contact: Russ Weeber (Aquatic Surveys Coordinator), Bird Studies Canada, P.O. Box 160, Port Rowan, Ontario, Canada N0E 1M0, (519)586-3531 fax (519)586-3532, rweeber@bsc-eoc.org, website: www.bsc-eoc.org or Kathy Jones Aquatics Survey Officer, Bird Studies Canada/Etudes d'Oiseaux Canada, P.O. Box 160, Port Rowan, ON; N0E 1M0, (519)586-3531 or 1-888-448-BIRD fax (519)586-3532, aqsurvey@bsc-eoc.org, website: www.bsc-eoc.org

Funding: The MMP has been funded since its beginning from a variety of sources. These sources are Great Lakes Protection Fund, Environment Canada, and the United States Environmental Protection Agency and Environment Canada.

Status: Ongoing.

58 Title: Habitat survey of heavily fished rainbow trout stream - Thunder Bay, Ontario

Stragegy: 4

Objective: The McIntyre River originates northwest of the City of Thunder Bay and flows 47.5 km to Lake Superior. Its lower third runs through the city before emptying into the Thunder Bay harbour. The river contains native brook trout in the upper reaches and is considered an excellent rainbow trout stream. In fact, it is one of the most heavily fished rainbow trout streams in the Canadian waters of Lake Superior largely because of its urban setting.

Since the completion of original aquatic habitat surveys in the mid-1970s, considerable urbanization and rural development has occurred in the McIntyre River corridor. Over the years, damage from physical disturbance of the aquatic and riparian environment and the infiltration of contaminants into the river system have affected this body of water. While some of this damage has occurred naturally, man-made disturbance has been more destructive. Several housing subdivisions have been completed or are in progress, with subsequent problems of storm water runoff, excessive sedimentation, and clearing of the river bank. The extent of habitat alteration associated with development and its affect on this important urban fishery, however, are not yet known. For this reason, existing habitat conditions and land use practices were recorded along the main channel of the McIntyre River to determine the biological health of the river and the surrounding land. The survey provides baseline information against which the results of remediation or the effects of further development in the nearshore area can be measured. Ultimately, the goal is to protect the productive capacity of existing fish habitat by regulating water and land use activities that affect the quality and quantity of the resource.

Partners: Ontario Ministry of Natural Resources, Fish and Wildlife Enhancement and Protection Fund.

Contact:

Funding: $20,000

Status: ongoing

59 Title: Habitat requirements of coaster brook trout in Lake Superior - Nipigon, Ontario

Strategy: 4

Objective: Lake dwelling brook trout (Salvelinus fontinalis) were historically widespread and common in the near shore waters of Lake Superior. These “coasters”, described as those brook trout that spend part of their life cycle in the Great Lakes, once provided a highly valued and productive fishery along the Lake Superior shoreline and in tributary streams. However, the population has declined over the years as a result of exploitation by angling, vulnerability to commercial fishing, and habitat loss and degradation.

A Brook Trout Rehabilitation Plan for Lake Superior was developed to maintain widely distributed, self-sustaining brook trout populations in areas that historically held viable populations. One of the objectives of the plan is to protect and restore riverine and lake habitat that supports coaster brook trout populations. To do this, a survey to quantify habitat use by brook trout and identify locations with suitable coaster habitat was needed.

A radio telemetry system will be used to document habitat use by coaster brook trout in Nipigon Bay and surrounding tributaries. In the spring of 1999, forty radio transmitters were implanted into the body cavity of adult brook trout captured in the Nipigon Bay area. The seasonal movement and location of radio tagged fish in the bay and in tributary streams will be recorded. Additional surveys to characterize lake and stream habitat will also be conducted.

Partners: Ontario Ministry of Natural Resources (Lake Superior Management Unit and Nipigon District), Centre for Northern Forest Ecosystem Research, U.S. Fish and Wildlife Service, Fish and Wildlife Enhancement and Protection Fund, and the Great Lakes Renewal Fund.

Contact:

Funding: $60,000

Status: ongoing

60 Title: Sea Lamprey control efforts in St. Marys River

Strategy:

Objective: Attempts to suppress Lake Superior's population of nonindigenous sea lamprey began with the creation of the Great Lakes Fishery Commission in 1955 which was formed, specifically, to control sea lamprey in the Great Lakes. Since then, the Commission has suppressed sea lamprey populations in most areas by 90 percent, paving the way for successful stocking, rehabilitation of native fisheries, and the resurgence of sport and commercial fishing. Despite this success, the St. Marys River remained a major trouble spot in the Great Lakes, producing more sea lampreys than all of the other Great Lakes combined. Sea Lampreys currently kill more fish in Lake Huron and northern Lake Michigan than commercial and sport fishing combined.

In order to determine the density of sea lamprey larvae in the substrates of the St. Marys River, an extensive habitat mapping project was completed and over 12,000 sites were sampled across the river during 1993 - 1996. The mapping was preparation for an ambitious plan, with the goal of reducing the river's sea lamprey production by 92 percent, by application of a granular, bottom -release formulation of the lampricide Bayluscide in the areas of highest larval concentration. This portion of the plan took place in 1998 and 1999. In addition, other efforts, including trapping and sterile-male-release were stepped up.

Estimates of the effectiveness of lampricide treatments in the river indicate that 45 percent of sea lamprey larvae have been eliminated. Lamprey traps located within the river, and on tributaries to the river, have removed 56 percent of the estimated 20,000 spawning sea lampreys while the sterile-male-release program has achieved a rate of 4.7 sterile males for every fertile male. Together, the integrated trapping and sterile-male-release efforts are estimated to have reduced the sea lamprey reproductive potential of the St. Marys by 92 percent.

Partners: Fisheries and Oceans Canada, the U.S. Fish and Wildlife Service, U.S. Geological Survey, the Chippewa-Ottawa Treaty Fisheries Management Authority, Michigan Department of Natural Resources and the Ontario Ministry of Environment.

Cost: Millions

Status: Ongoing

61 Title: Risk Analysis of the Aquatic Resources in Pictured Rocks National Lakeshore: An Ecologically Based Inventory and Estimation of the effects of Land Use Practices

Strategy:

Objective: Assess the impact that land use practices in and around the park affect park resources, keying in on aquatic systems.

Results: The project will help determine if there are any major problems arising from harmful land use practices and will also identify sensitive areas that should be protected to preserve the integrity of natural systems within the park.

Partners: USGS-BRD, Pictured Rocks National Lakeshore

Contact: Terence Boyle, USGS-BRD, Ph: (970) 491-1452, E-mail: tpboyle@cnr.colostate.edu

Funding: not applicable

Status: completed 1998

62 Title: Superior Coastal Wetland Initiative Phase I

Strategy: 14

Objective: This proposal is phase one of four projected phases of this landscape scale coastal wetland preservation and restoration initiative. The project emphasizes land stewardship combined with protection and restoration of 8,180 acres of wetlands and 6,359 acres of uplands in the Lake Superior watershed in Wisconsin. The two most critical threats to coastal wetlands in Lake Superior are development and non-point source pollution, particularly sedimentation. This initiative has brought together all of the major natural resource entities in the basin to begin breaking down old barriers in working relationships to combine technical, biological, and cultural expertise to create the most efficient working group to address the resource needs of the basin. Unlike many places in the United States, many of the coastal wetland acres remain intact, and if preserved through easement or fee title acquisition, the basins themselves will remain protected from development. A far greater threat remains in the form of non-point source pollution. It is essential to reduce the sediment load into tributary streams and thus the emphasis on upland activities in this proposal. No component can be singled out, all of the players and elements must work together to preserve the greatest concentration of coastal wetlands, dunes and bottomland forest in the Upper Great Lakes and the migratory birds and other wildlife these habitats support.

Results: 1,049 acres have been purchased and placed into protective status. Over 4,000 acres of uplands are under management agreement ensuring stewardship of agricultural lands in the Lake Superior watershed. Twenty-nine acres of wetlands have been restored.

Contact: Pam Dryer, Wildlife Biologist, U.S. Fish and Wildlife Service, 2800 Lakeshore Dr. E., Ashland, WI, 54806, 715-682-6185 ext 215, pam_dryer@fws.gov.

Partners: U.S. Fish & Wildlife Service, Bad River Band of Lake Superior Chippewa, Red Cliff Band of Lake Superior Chippewa, Wisconsin Department of Natural Resources, The Nature Conservancy, Ducks Unlimited, Trout Unlimited, Douglas, Bayfield, Ashland, Iron Counties, private landowners, Great Lakes Indian Fish & Wildlife Commission, and Chequamegon Chapter of the Audubon Society

Funding: $3.2 million from partners and $878,000 from a North American Wetland Conservation Act grant

Status: Performance period for this phase will end September 2001. The partnership is developing a Phase II grant application.

63 Title: Habitat requirements of lake sturgeon in the Kaministiquia River – Thunder Bay, Ontario

Objective: Lake sturgeon (*Acipenser fulvescens*) are distributed throughout the Lake Superior basin with concentrations found near spawning tributaries in the United States and Canada. Lake Superior stocks were decimated during the development of the commercial fishery in the early part of the 19th century. Initially, low commercial value of lake sturgeon, coupled with the tendency of these fish to destroy fishing nets, prompted most fishermen to regard lake sturgeon as a nuisance that should be removed and eliminated. However, by 1860, lake sturgeon had begun to command high prices and fishermen targeted the species, hastening their decline. The construction of dams blocking access to traditional spawning grounds, log drives in large rivers and streams causing scouring of the bottom or littering of substrates with bark, shoreline development, dredging of river channels for shipping, and the effects of pollution have also impacted lake sturgeon populations.

The goal for lake sturgeon rehabilitation in Lake Superior is to maintain, enhance, and rehabilitate self-sustaining populations where the species historically occurred basin wide. Working towards this goal, the Lake Superior Management Unit is conducting a survey to quantify spawning, nursery, rearing, and foraging habitat and migration routes of lake sturgeon in the Kaministiquia River, a tributary to Lake Superior. The survey will also be used to document seasonal distribution and movement patterns of adult and juvenile sturgeon in order to identify critical habitat sites within the Kaministiquia River system.

Partners: Ontario Ministry of Natural Resources, Environment Canada, and the Ontario Federation of Anglers and Hunters.

Contact: Ken Cullis, Ontario Ministry of Natural Resources, Lake Superior Management Unit. Phone: (807) 475-1375 email: ken.cullis@mnr.gov.on.ca

Funding: $30,000

Status: ongoing

Education and Public Involvement

64 Title: "Keeping Nature in Your Community: Using Ecosystem-based Processes to Restore Our Communities" workshops

Strategy: 34

Objective: "Keeping Nature in Your Community" is a two-day training program designed to provide tools for the creation of healthy, vibrant and sustainable communities. This program has been developed over the last six years and has been presented in various formats to public and private agencies and individuals in over 30 states throughout the country and abroad. Workshop objectives include; creating a framework for decision making that builds upon a public visioning and participation process, Create an awareness of the economic and social values associated with healthy ecosystems, demonstrate the importance of community participation in establishing a vision to guide future growth and development, improve decision-making using environmental information to meld growth with natural patterns, increase effective partnerships combining state and local financial and technical resources with grass roots activism to resolve local problems ? locally, and provide incentives for participants to initiate a comprehensive strategy for natural resources stewardship in their jurisdiction and with adjoining jurisdictions as needed.

Results: In 1998 and 1999 a series of seven "Keeping Nature in Your Community" workshops were held in Minnesota provided hands-on training to 171 participants. The workbook at the core of the curriculum (which previously focused on community forestry) was updated to be more inclusive of all community natural resource concerns. New materials were also added to the workshop and workbook on urban sprawl as well as land protection practices during development processes.

The workshop actively demonstrated an innovative planning framework, built upon a natural systems foundation. In two full days of training the workshop provides: brief presentations on ecosystem process vocabulary, concepts, and practical tools, local & national case studies - stories of how ecosystem approaches have been used successfully in a range of project types and scales, hands-on exercises demonstrating techniques for involving the community, ideas on local planning & natural resource issues, displays, handout materials, & useful resource list on land use planning, natural resources, etc., and a copy for each participant of the workshop manual - "Using Ecosystem-Based Processes to Restore Our Communities" - a step-by-step guide for applying techniques in local projects

Partners: Minnesota Department of Natural Resources, Tree Trust, Minnesota Legislature, 4 Red River Resource Conservation and Development Councils, various local cooperators (including the City of Duluth)

Contact: Peggy Sand, Minnesota Department of Natural Resources, 1200 Warner Road, St. Paul, MN 55106, (651)772-7562, peggy.sand@dnr.state.mn.us

Funding: $50,000 general fund appropriation from the Minnesota Legislature, $9,000 from Department of Natural Resources, Metro Region, Community Technical Assistance funds, $1,000 from 4 Red River Resource Conservation and Development Councils, $9,600 in registration fees from recipients ($130 per person for full registration, $30 per person for community volunteers receiving scholarships), significant in kind contributions (staff time and materials) from Minnesota Department of Natural Resources, Metro Region, Division of Forestry.

Status: Completed

The 1998-99 workshops were completed. Additional workshops in the northwestern part of Minnesota are being planned. Additional workshops can be given upon request pending local sponsorship and funding availability.

65 Title: Adopt-a-River Program, MN

Strategy: 33

Objective: Increase public awareness of watershed issues, stressing that "the river begins on your street" and "it matters what the water is like" as it flows off your property. Sponsors cleanup events annually for purposes of advancing public awareness through service. It is also involved in environmental education either in the classroom, river boat or water festivals, and at the state fair. Communication also takes place in a newsletter.

Results: 250 groups registered on 900 miles of shoreline, with 2/3 of the donated hours on a 2,000-mile network of canoe and boating routes. 50 percent of rubbish removed is from these same routes. In 1998, 5,000 volunteers worked 13,000 hours to remove 270,000 pounds of rubbish.

Partners: Government partners include Sentencing-to-Service (Department of Corrections), Minnesota Department of Natural Resources, Minnesota Conservation Corps/Americorps, Minnesota Pollution Control Agency, Minnesota National Guard, Soil and Water Conservation Districts, county solid waste/environmental and water plan offices, and the Minnesota River Basin Joint Powers Board. In addition, various corporate sponsors provide supplies, funding and/or services in kind.

Contact: Paul E. Nordell, Coordinator, Minnesota Department of Natural Resources, 500 Lafayette Road, Saint Paul, Minnesota 55155-4052, 651-297-5476, e-mail: paul.nordell@dnr.state.mn.us; Website: http://www.dnr.state.us/trails_and_waterways/adopt_river.html

Funding: Operating budget of $10,000, with staff of 1.8 persons, including an Americorps member. In addition, corporate partnerships exist for supplies and certain in-kind services

Status: Ongoing.

66 Title: Minnesota's Lake Superior Coastal Program (MLSCP)

Strategy: 32

Objective/need: To balance competing economic development pressures and natural resource conservation and protection needs of the Minnesota's Lake Superior shoreline, St. Louis River estuary and Duluth Harbor. The MLSCP is a federally approved Coastal Zone Management Program through the Coastal Zone Management Act. In Minnesota, this program will be operated primarily as a pass-through grant program to local municipalities, state agencies, organizations, universities, etc. The program is just beginning implementation and is waiting for the Coastal Council to be approved by Governor Ventura before the program can begin its first grant cycle.

Results: None to date.

Partners Eligible partners include state agencies, local units of government within the coastal boundary, school districts, universities, soil and water conservation districts, non profit organizations, and regional planning agencies.

Contact: Tricia Ryan, Program Coordinator, MLSCP, Minnesota Department of Natural Resources Waters Division,1568 Highway 2, Two Harbors, MN 55616, 218-834-6625 phone 218-834-6639 fax, tricia.ryan@dnr.state.mn.us

Funding: $450,000-480,000 federal funds to be matched 50/50 with non-federal funds.

Status: ongoing

67 Title: Community Education about Nonpoint Pollution and Exotic Species

Strategy: 32

Objective: Working together to restore, protect and enhance the St. Louis River. Raise awareness and educate people about nonpoint pollution, and purple loosestrife and its control. This project will focus on the St. Louis River Area of Concern implementing high priority recommendations from the St. Louis River Remedial Action Plan.

Results: None to date. Most of this work will take place in the year 2000.

Partners: St. Louis River Citizens Action Committee Minnesota Sea Grant, the Natural Resources Conservation Service, Soil and Water Conservation Districts, Miller Creek Joint Powers Board, city government, golf course managers, plant nurseries, area schools and others.

Contact: Karen Plass, St. Louis River Citizens Action Committee, 218-733-9520, slrcac@stlouisriver.org, www.stlouisriver.org or www.epa.gov/glnpo/aoc/stlouis.html

Funding: $13,001 ($12,288 from U.S. EPA, matched with $712 from the St. Louis River Citizens Action).

Status of the project: Estimated completion date, May 2000.

68 Title: Community cleanup of waterfront property - Thunder Bay, Ontario

Strategy: 33

Objective: “Wake Up to Your Waterfront” is a community based cleanup of Thunder Bay harbour and its tributaries. Since the development of this project in 1993, the commitment and dedication of numerous volunteers has demonstrated that there is a high level of public interest in preserving the waterfront environment. In 1997, the cleanup was incorporated into the City"s "Spring-up to Clean-up" campaign.

The success of this annual event has served as a demonstration model for similar community based cleanups. As a result, municipal shoreline cleanups were expanded to include the entire Lake Superior shoreline. To co-ordinate cleanup activities the “Great Lake Superior Cleanup” project was developed in 1995 under the Lake Superior Binational Program. These events are designed to enhance public awareness of the significance of Lake Superior and the long-term impact of careless waste disposal and littering.

Partners: City of Thunder Bay, Lake Superior Programs Office, Ontario Ministry of Natural Resources, Environment Canada, Ontario Ministry of the Environment, Lake Superior Binational Program, and the Great Lakes 2000 Cleanup Fund.

Contact: Ken Cullis, Ontario Ministry of Natural Resources, Lake Superior Management Unit, (807) 475-1375, ken.cullis@mnr.gov.on.ca

Funding: $20,000/year

Status: ongoing

69 Title: Deer Marsh Wetland Protection and Public Education

Stragegy: 33

Objective: Trail work to accomplish several goals: reduce grade to make trail more accessible, clear brush and fallen trees from trail, provide wildlife viewing opportunities and enhance wildlife habitat, educate the public on importance of wetland preservation and wetland associated communities. Relocate road away from wetlands to eliminate sediment runoff.

Results: Increased public understanding of wetland communities and importance

Partners: USFS Ottawa NF, MI DNR, National Heritage Program, Ottawa Interpretive Association, Trale UP, Sierra Club

Contact: Dave Pickford or Joann Thurber, USFS Ottawa NF, Ph: (906) 852-3500, E-mail: dpickford/r9_ottawa@fs.fed.us

Funding: Multi-funded partnership involving volunteers, non-profit/appropriated dollars and in-kind labor and materials

Status: completed

70 Title: HabCARES

Stragegy: 14

The International Workshop on the Science and Management for Habitat Conservation and Restoration Strategies (HabCARES) brought a diverse group of participants together in 1994 to investigate the effect of human intervention on terrestrial and aquatic habitat. Through implementation of the Lake Superior Remedial Action Plans and Lake Superior Binational Program, it became apparent that an international symposium focused on current resource management issues, was timely. As a result, symposium participants were challenged to assess and synthesize the understanding of the linkages between habitat, production, and structure of aquatic and wetland communities, identify successful habitat restorations and enhancements, identify and fill important gaps in scientific knowledge and provide recommendations to resource managers to effectively conserve, restore, and enhance aquatic habitat.

Results: Products of HabCARES included the publications of workshop proceedings in the Canadian Journal of Fisheries and Aquatic Sciences (Vol 53, Sup.1, 1996) and publication of the methods manual “Methods of Modifying Habitat to Benefit the Great Lakes Ecosystem” in Canadian Institute for Scientific and Technical Information, Occasional Paper No. 1, 1995. In addition, a number of technical transfer sessions were successfully organized following the workshop.

Partners: Canada Department of Fisheries and Oceans, Environment Canada’s Great Lakes 2000 Cleanup Fund, Habitat Advisory Board of the Great Lakes Fisheries Commission, Ontario Ministry of Natural Resources, U. S. Environmental Protection Agency, and U. S. Fish and Wildlife Service.

Status: Complete

71 Title: Partners for Fish and Wildlife

Strategy: 11

Objective: This program can increase fish and wildlife populations on private lands through habitat restoration and management projects that will blend wildlife conservation with profitable land use. Most of the habitat work entails the restoration of shallow, depressional wetlands by plugging ditches or breaking subsurface drainage tile. Other habitat projects consist of planting upland areas next to wetlands to native vegetation to encourage wildlife nesting and to provide ground cover, as well as streambank stabilization and in-stream habitat improvement.

Results: To date 4,715 acres of wetlands have been restored in the Lake Superior basin through this program.

Contact: Pam Dryer, Wildlife Biologist, U.S. Fish and Wildlife Service, 2800 Lakeshore Dr. E., Ashland, WI, 54806, 715-682-6185 ext 215, pam_dryer@fws.gov.

Partners: Landowners, local conservation groups

Funding: Variable

Status: Ongoing

Other Projects

Information about important projects is still being collected. Some contact people have submitted information that has yet to be summarized. In other cases, contacts with lead agency personell need to be made. Projects for which information has not yet been summarized includes the following:

Habitat Restoration and Rehabilitation

72. Little Rapids Restoration
73. Munuscong River Restoration Project
74. St. Louis River Wild Rice Restoration, Fond du Lac, MN
75. Waishkey Bay Wild Rice Restoration
76. Lake Superior College Riparian Forest Restoration, Duluth, MN
77. Scales Creek Project, Houghton, MI
78. Torch Lake Project, MI
79. Big Creek Stream Restoration, MI
80. Lincoln Park Improvement, Duluth, MN
81. Purple Loosestrife Project, MN
82. Mined Land Reclamation, Duluth, MN
83. Brule River Habitat and Stream Improvement, Brule, WI
84. Chequamegon Bay Aquatic Vegetation Restoration, WI

85. Whittlesey Creek Stabilization and Rehabilitation Demonstration, Bayfield, WI
86. Lake Superior Basin Brook Trout Brood Stock Facility, WI
87. Marathon Marina Development - Habitat Enhancement/Sediment Remediation
88. Stream Habitat improvement Completed. Sue Reinke.
89. Wilson Flowage Dam Restoration
90. Sandy Beach (Wawa, ON) Sand Dune Restoration Project
91. St. Marys River Spoils Islands Armoring
92. Tahquameonon River Restoration
93. Sucker River Restoration

Special Designations and Acquisition

94. Keweenaw Shoreline Protection, MI
95. Icelandite Coastal Fen Scientific and Natural Area, MN
96. Wetlands Reserve Program, WI
97. Wildlife Habitat Incentives Program, WI

Watershed Management and Forest Stewardship

98. Whetstone Creek Project, Marquette County, MI
99. Brule River State Forest, Brule, WI
100. Kakagon Sloughs Plan Implementation and Sustainability Analysis, WI
101. Forest -wide Sediment Reduction/interception
102. National Forest Master Planning

Monitoring, Assessment and Inventory

103. Whitefish Bay, MI (substrate map)
104. Biological Survey of the North Shore Highlands Subsection, MN
105. Coaster Brook Trout Habitat in Grand Portage Area, MN
106. Stream Restoration Tech study
107. Comprehensive hydrologic assessment of the Whittlesey Creek watershed
108. Thunder Bay Waterfront Development Plan - Habitat Enhancement Strategy
109. Physical Habitat Classification of Nearshore Waters of Thunder Bay and Black Bay
110. Status of Walleye Stocks and Habitat Quality in Batchawana Bay and the St. Mary"s River
111. Identifying and Protecting Priority Aquatic Sites

Education and Public Involvement

112. Isle Royale National Park, MI
113. Great Lakes Aquarium, Duluth, MN
114. Citizen Lake Monitoring Program, MN
115. Northern Great Lakes Visitors Center, Ashland, WI

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ADDENDUM 6-A. RARE PLANT AND ANIMAL SPECIES FROM THE LAKE SUPERIOR BASIN

This list is a compilation and comparison of the species listed as Endangered (END), Threatened (THR), Special Concern (SC/M) or Vulnerable (VUL) in one or more of the state, provincial, or federal jurisdictions. It remains under development and will continue to be refined in subseauent drafts of the report. It is intended to allow for whole basin comparisons of species status and to allow for analysis of habitat influences to species status in the basin. These species are found in the LSB. They may not be rare in the basin, but may be listed because of rarety elsewhere. It is important to note that som species such as the Kiyi are not apparently rare in the basin. For these species, their best remaining habitat may exist in the Lake Superior basin.

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		Can	US	ON	MN	WI	MI	Comments
Birds								
Accipiter gentilis	northern goshawk					SC/M		
Ammodramus leconteii	Le Conte's sparrow					SC/M		
Anas americana	American wigeon					SC/M		
Anas discors	blue-winged teal					?		
Anas rubripes	America black duck					SC/M		
Asio otus	long-eared owl					SC/M		
Aythya affinis	lesser scaup					SC/M		
Aythya americana	redhead					S2B, SZN		
Bartramia longicauda	upland sandpiper					S2B, SZN		
Botaurus lentiginosus	American bittern					S3B, SZN		
Bucephala albeola	bufflehead			S3B				
Bucephala clangula	common goldeneye					SC/M		
Buteo lineatus	red-shouldered hawk	VUL		S4B (VUL)		THR	THR	MI: Population holding its own, but variety of threats exist including habitat destruction
Carduelis pinus	pine siskin					SC/M		
Catharus fuscescens	veery					?		
Catharus ustulatus	Swainson's thrush					SC/M		

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		Can	US	ON	MN	WI	MI	Comments
Charadrius melodus	piping plover	END	LELT	S1		END	END	MI: Loss of nesting habitat
Chlidonias niger	black tern			S3B		SC/M	SC	MI: Habitat alteration and degradation threaten the species
Circus cyaneus	northern harrier					SC/M		
Coccothraustes vespertin	evening grosbeak					SC/M		
Coturnicops noveboracensis	yellow rail				SPC	SC/M	THR	MI: Major threat is nesting habitat destruction by humans
Cygnus buccinator	trumpeter swan					END		
Dendroica caerulesc	black-throated blue warbler					SC/M		
Dendroica cerulea	cerulean warbler						SC	MI: Decline apparently is due primarily to habitat loss and fragmentation, perhaps primarily in winter range
Dendroica fusca	blackburnian warbler					?		
Dendroica tigrina	Cape May warbler					SC/M		
Dolichonyx oryzivorus	bobolink					?		
Empidonax flaviventris	yellow-bellied flycatcher					SC/M		
Falco columbarius	merlin					SC/M	THR	MI: Current threats are hab. loss and organochlorine use in Central Am.
Falco peregrinus	peregrine falcon		E(S/A)	S2B (END)	THR		END	MI: Main threats pesticides and human takings
Gavia immer	common loon					?	THR	
Haliaeetus leucocephalus	bald eagle		LTNL	S3B (END)	SPC	?	THR	
Ixobrychus exilis	least bittern					SC/M		
Lanius ludovicianus migrans	migrant loggerhead shrike						END	
Mergus merganser	common merganser					SC/M		
Mergus serrator	red-breasted merganser					SC/M		
Oporornis agilis	Connecticut warbler					SC/M		
Pandion haliaetus	osprey					THR	THR	MI: Primary threat was and is organochlorines
Parus hudsonicus	boreal chickadee					SC/M		
Pelecanus erythrorhynchos	American white pelican			S3				

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		Can	US	ON	MN	WI	MI	Comments
				(END)				
Perisoreus canadensis	gray jay					SC/M		
Phalacrocorax auritus	double-crested cormorant							
Picoides arcticus	black-backed woodpecker					SC/M		
Podiceps grisegena	red-necked grebe			S3B				
Regulus calendula	ruby-crowned kinglet					?		
Sterna caspia	Caspian tern	VUL		S3B (VUL)		END		
Sterna hirundo	common tern				THR	END	THR	WI: Habitat loss is one factor in decline of this species.
Strix nebulosa	great gray owl			S3S4				
Surnia ulula	northern hawk owl			S3S4				
Tympanuchus phasianellus	sharp-tailed grouse					?		
Vermivora chrysoptera	golden-winged warbler					?		
Vermivora peregrina	Tennessee warbler					SC/M		
Vermivora ruficapilla	Nashville warbler					?		
Wilsonia pusilla	Wilson's warbler					?		
Fish								
Acipenser fulvescens	lake sturgeon			S3	SPC	SC/H	THR	MI: Physical habitat destruction and overfishing are primary threats
Coregonus bartlettii	Siskiwit Lake cisco						SC	
Coregonus hubbsi	Ives Lake cisco						SC	MI: Known only in one lake in the LS basin
Coregonus kiyi	kiyi	VUL		S3?	SPC			
Coregonus reighardi	shortnose cisco	THR		SX				
Coregonus zenithicus	shortjaw cisco	THR		S2	SPC			
Ichthyomyzon fossor	northern brook lamprey	VUL		S3				
Ichthyomyzon unicuspis	silver lamprey			S3				
Lampetra appendix	American brook lamprey			S3				
Myoxocephalus thompsoni	deepwater sculpin	THR						
Polyodon spathula	paddlefish	EXP		SX				

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		Can	US	ON	MN	WI	MI	Comments
Herptiles								
Clemmys insculpta	wood turtle				THR	THR		
Emydoidea blandingii	Blanding's turtle				THR			
Pseudacris triseriata maculata	boreal chorus frog						SC	
Terrapene carolina carolina	eastern box turtle						SC	
Invertebrates								
Aeshna eremita	lake darner					SC/N		
Aeshna tuberculifera	black-tipped darner					SC/N		
Boloria eunomia	bog fritillary					SC/N		
Boloria freija	freija fritillary					SC/N		
Boloria frigga	frigga fritillary					SC/N		
Boloria titania	purple lesser fritillary					SC/N		
Caenis youngi	a caenid mayfly					SC/N		
Chromagrion conditum	aurora damselfly					SC/N		
Cicindela hirticollis	beach dune tiger beetle			S3?		SC/N		ON: Though it's currently ranked S3?, it's probably now just barely that and possibly even S2.
Cordulegaster obliqua	arrowhead spiketail					SC/N		
Elaphrus lapponicus	subarctic ground beetle			S1?				ON: Currently known only from a single site on the north shore of Lake Superior.
Elliptio complanata	eastern elliptio					SC/H		
Enallagma vernale	gloyd's bluet					SC/N		
Hesperia comma	Laurentian skipper					SC/N		
Lepidostoma libum	a bizarre caddisfly					SC/N		
Lycaeides idas nabokovi	Nabokov's blue		END		SPC		THR	
Lycaena dorcas	dorcas copper					SC/N		
Lycaena epixanthe	bog copper					SC/N		
Lycaena xanthoides	great copper					SC/N		
Melanoplus flavidus	blue-legged grasshopper					SC/N		

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		Can	US	ON	MN	WI	MI	Comments
Oeneis jutta	jutta arctic					SC/N		
Ophiogomphus anomalus	extra-striped snaketail			S2				
Ophiogomphus carolus	riffle snaketail					SC/N		
Oreodytes scitulus	a predaceous diving beetle					SC/N		
Papilio machaon	old world swallowtail			S2S3				
Phyciodes batesii	tawny crescent spot					SC/N		
Planogyra asteriscus	eastern flat-whorl						SC	
Planorbella corpulenta whiteavesi	Whiteave's capacious ram's-horn			SH				ON: Known to have occurred in the province only in Lac des Mille Lacs and Greenwater Lake in the Lake Superior basin.
Planorbella multivolvis	acorn ram's horn						END	
Sanfilippodytes pseudovillis	a predaceous diving beetle					SC/N		
Somatochlora elongata	ski-tailed emerald					SC/N		
Somatochlora incurvata	incurvate emerald						SC	
Stylogomphus albistylus	least clubtail					SC/N		
Stylurus scudderi	zebra clubtail			S3		SC/N		
Sympetrum danae	black meadowhawk					SC/N		
Trimerotropis huroniana	Lake Huron locust						THR	
Williamsonia fletcheri	Canadian bog skimmer						S1S	
Mammals								
Alces alces	moose					SC/P	SC	
Canis lupus	gray wolf						END	
Felis concolor couguar	eastern cougar	END	END	SH				
Lynx canadensis	lynx				NON		END	
Martes americana	American marten						THR	MI: Extirpated in many areas, is coming back, logging still a threat
Microtus chrotorrhinus	rock vole			S3S4				ON: Probably not as rare as previously thought.
Myotis leibii	eastern small-footed bat			S2S3				ON: There was a hibernaculum near Alona Bay (Algoma), but it probably hasn't been checked for some time and may be an 'H'-

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		Can	US	ON	MN	WI	MI	Comments
								ranked occurrence.
Myotis septentrionalis	northern myotis				SPC			
Pipistrellus subflavus	eastern pipistrelle			S3?	SPC			
Rangifer tarandus	caribou	VUL	VUL	S3S4?				
Plants								
Adlumia fungosa	climbing fumitory						SC	
Adoxa moschatellina	muskroot			S1	SPC	THR		
Agrostis geminata	twin bentgrass				SPC			
Allium schoenoprasum	chives				THR		THR	
Amerorchis rotundifolia	round-leaved orchis						END	
Ammophila breviligulata	American beachgrass			S3	THR			
Antennaria parvifolia	pussy-toes			S1				
Antennaria rosea	pussy-toes			S1			EXTR	
Arabis divaricarpa var dacotica	purple rock-cress			S3?				
Arabis holboellii var retrofracta	Holboell's rock-cress				THR			
Arenaria humifusa	low sandwort			S2S3				
Arethusa bulbosa	swamp-pink					SC		
Armoracia lacustris	lake-cress					END	THR	WI: Lake Superior estuaries, and quiet waters of lakes and streams, hab. requirements not well characterized
Arnica cordifolia	heartleaf arnica			S1			THR	
Arnica lonchophylla ssp. Chionopappa	snowy arnica			S1	THR			
Artemisia frigida	prairie sagebrush			S2S3		SC		
Asplenium montanum	mountain spleenwort						EXTR	
Asplenium rhizophyllum	walking-fern spleenwort						THR	
Asplenium ruta-muraria	wallrue spleenwort			S2				
Asplenium trichomanes	maidenhair spleenwort				THR	SC		
Asplenium trichomanes-ramosum	green spleenwort						THR	

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		Can	US	ON	MN	WI	MI	Comments
Aster longifolius	long-leaved aster						SC	
Aster modestus	great northern aster						THR	
Astragalus canadensis	Canadian milkvetch						THR	
Astragalus neglectus	Cooper's milkvetch					END	SC	MI: Principal threat is the loss of a periodic disturbance regime
Athyrium filix-femina var. Cyclosorum	lady fern			SH				
Bartonia paniculata	twining bartonia						END	
Beckmannia syzigachne	American sloughgrass						THR	
Botrychium acuminatum	pointed moonwort			S1			THR	MI: Recently described species that is both rare and local
Botrychium campestre	prairie dunewort			S1		END	THR	MI: Plowing of native prairies is primary threat
Botrychium hesperium	western moonwort			S1			THR	MI: Threats not well understood
Botrychium lanceolatum	narrow triangle moonwort			S3	THR			
Botrychium lunaria	moonwort grape-fern				THR	END		WI: Cool, moist sandy soils under forest cover, very rare and hard to identify.
Botrychium minganense	Mingan's moonwort				SPC	SC		
Botrychium mormo	little goblin moonwort				SPC (DROP)	END		
Botrychium pallidum	pale moonwort			S1	END			
Botrychium pseudopinnatum	false northwestern moonwort			S1	?			
Botrychium rugulosum	rugulose grape-fern				THR	SC		
Botrychium simplex	least moonwort				SPC			
Botrychium spathulatum	spoon-leaf moonwort			S1		SC		
Braya humilis	low braya						THR	MI: Canadian species
Bromus inermis ssp. pumpellianus	Pumpell's brome grass			SH				
Calamagrostis lacustris	marsh reedgrass				SPC		END	
Calamagrostis purpurascens	purple reed-grass			S1	SPC			
Calamagrostis stricta	slim-stem small reedgrass					SC		
Callitriche hermaphroditica	autumnal water-starwort					SC	SC	

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		Can	US	ON	MN	WI	MI	Comments
Callitriche heterophylla	large water starwort			S2?		THR		
Caltha natans	floating marsh-marigold					END		WI: Wet, open shorelines of quiet streams or ponds, one known site
Calylophus serrulatus	yellow evening primrose					SC		
Calypso bulbosa	fairy slipper					THR	THR	MI: Harvesting of cedar is worst threat, circumboreal spp WI: Deep, moist, coniferous forests and white cedar swamps, most sites have old-growth characteristics.
Cardamine maxima	large toothwort					SC	THR	
Carex arcta	sedge							
Carex assiniboinensis	Assiniboine sedge					SC	THR	
Carex atratiformis	black sedge			S2			THR	
Carex capillaris	hair-like sedge					SC		
Carex concinna	beautiful sedge					THR		WI: Shaded beach ridges and swales and open, moist, sandy soil, difficult to identify
Carex davisii	Davis's sedge						SC	
Carex exilis	coast sedge					THR		WI: Open sedge sphagnum, sphagnum bogs, and rear dune beach pools along the Great Lakes, difficult to identify
Carex flava	yellow sedge				SPC			
Carex katahdinensis	Katahdin sedge				THR			
Carex lenticularis	shore sedge					THR		WI: Difficult to identify in the field
Carex livida var radicaulis	livid sedge					SC		
Carex loliacea	sedge			S2				
Carex media	sedge						THR	
Carex michauxiana	Michaux sedge				SPC	THR		WI: Difficult to identify in the field
Carex pallescens	pale sedge						SC	
Carex pallescens var neogaea	pale sedge				END	SC		
Carex prasina	drooping sedge					THR		WI: Difficult to identify in the field; requires closed canopy
Carex praticola	northern meadow sedge			S2?	SPC			
Carex richardsonii	Richardson's sedge						SC	

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		Can	US	ON	MN	WI	MI	Comments
Carex rossii	short sedge			S2			THR	
Carex schweinitzii	Schweinitz's sedge					END		
Carex scirpoidea	bulrush sedge						THR	
Carex squarrosa	sedge						SC	
Carex supina	sedge			S1	SPC			
Carex tenuiflora	sparse-flowered sedge					SC		
Carex tincta	tinged oval sedge			S1				
Carex vaginata	sheathed sedge					SC		
Carex wiegandii	Wiegand's sedge			S1			THR	MI: Hydrological alteration of habitat appears to be a primary threat
Carex xerantica	dry sedge			S1	SPC			
Castilleja septentrionalis	Labrador indian-paintbrush						THR	
Ceanothus sanguineus	Oregon-tea						THR	
Ceratophyllum echinatum	prickly hornwort			S3		SC		
Chamaerhodos erecta ssp. nuttalli	Keweenaw rock-rose						END	MI: One fairly small population on the Keweenaw Peninsula of Michigan
Chenopodium leptophyllum	narrow-leaved goosefoot			S1				
Cirsium drummondii	Drummond's thistle			S1				
Cirsium flodmanii	Flodman thistle			S2?		SC		
Cirsium pitcheri	dune thistle	VUL	THR	S2		THR	THR	MI: Manipulation of shoreline habitat continues to threaten existing populations and dynamic dune processes essential for habitat maintenance
Claytonia carolinana	Carolina spring beauty				SPC			
Clematis occidentalis	purple clematis						SC	
Collinsia parviflora	small-flower blue-eyed mary			S2			THR	
Corispermum americanum	bugseed			S1S3				
Corispermum pallasii	bugseed			S1S3				
Corispermum villosum	bugseed			S1S3				
Crataegus douglasii	Douglas's hawthorn				THR		SC	
Cryptogramma acrostichoides	American rock-brake						THR	MI: Common in Canada
Cryptogramma stelleri	slender cliff-brake						SC	

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		Can	US	ON	MN	WI	MI	Comments
Cuscuta cephalanthi	button-bush dodder			S2				
Cypripedium arietinum	ram's-head lady's-slipper			S3		THR	SC	MI: Human habitat destruction is a primary factor WI: Cold, coniferous swamps and bogs, open alkaline sedge swales with white cedar, and sandy, old dunes bordered by conifers
Cypripedium reginae	showy lady's-slipper					SC		
Cystopteris laurentiana	Laurentian bladder fern			S2S3			SC	
Cystopteris montana	mountain bladder fern			S1				
Danthonia compressa	flattened oatgrass						THR	
Danthonia intermedia	Vasey oatgrass						SC	
Dentaria maxima	large toothwort						THR	
Deschampsia cespitosa	tufted hairgrass					SC		
Deschampsia flexuosa	slender hairgrass				SPC	SC		
Diphasiastrum sabinifolium	ground-fir			S3			SC?	
Disporum hookeri	hooker mandrin						END	
Draba glabella	rock Whitlow-grass				SPC		THR	
Draba incana	hoary Whitlow-grass						THR	
Draba norvegica	Norwegian Whitlow-grass				END			
Drosera anglica	English sundew					THR	SC	
Drosera linearis	slenderleaf sundew					THR		
Dryas drummondii	yellow dryas			S1				
Dryopteris expansa	spreading woodfern					SC	SC	
Dryopteris filix-mas	male fern					SC	THR	
Dryopteris fragrans	fragrant cliff woodfern						SC	
Dryopteris fragrans var remotiuscula	fragrant fern					SC?		
Elatine triandra	long-stemmed waterwort			S3		SC		
Eleocharis nitida	slender spike-rush				THR	END		
Eleocharis robbinsii	Robbins spikerush					SC		
Elymus glaucus	blue wild-rye			S1			SC	
Elymus mollis	American dune wild-rye						SC	

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		Can	US	ON	MN	WI	MI	Comments
Elymus smithii	western wheatgrass			S1?				
Elymus virginicus var. Submuticus	wild rye			S2?				
Elytrigia spicata	bluebunch wheatgrass						EXTR	
Empetrum eamesii	purple crowberry				END			
Empetrum nigrum	black crowberry				END		THR	
Epilobium palustre	marsh willow-herb					SC	SC	
Epilobium strictum	downy willow-herb					SC		
Equisetum palustre	marsh horsetail					SC		
Equisetum telmateia	giant horsetail						EXTR	
Equisetum variegatum	variegated horsetail					SC		
Erigeron glabellus	smooth fleabane			S1				
Euphrasia frigida	cold-weather eyebright						THR	
Euphrasia hudsoniana	Hudson Bay eyebright				SPC			
Euphrasia nemorosa	common eyebright						THR	
Festuca hallii	rough fescue			S1				
Galearis spectabilis	showy orchis						THR	
Galium kamtschaticum	boreal bedstraw			S2				
Gentiana linearis	narrow-leaved gentian						THR	
Glycyrrhiza lepidota	wild licorice					SC		
Gnaphalium sylvaticum	woodland cudweed					SC		
Gratiola aurea	golden hedge-hyssop						THR	
Gymnocarpium jessoense	northern oak fern			S3		SC	SC?	
Gymnocarpium robertianum	limestone oak fern			S2		SC	SC	
Helianthus mollis	downy sunflower						THR	
Heterotheca villosa	prairie golden aster			S1				
Hieracium venosum	rattlesnake hawkweed			S2				
Hudsonia tomentosa	sand-heather			S2S3	SPC			
Huperzia appalachiana	Appalachian fir clubmoss			S1				WI: newly reported, no official rank
Huperzia selago	fir clubmoss			S3S4		SC	SC	
Juncus greenei	Greene's rush			S3				
Juncus longistylis	long-styled rush			S3				

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		Can	US	ON	MN	WI	MI	Comments
Juncus stygius	moor rush					END	THR	
Juncus subtilis	creeping rush			S3				
Juncus vaseyi	Vasey rush			S3		SC		
Juniperus horizontalis	creeping juniper				SPC			
Koeleria macrantha	june grass			S2				
Lactuca pulchella	blue lettuce						THR	
Leucophysalis grandiflora	large-flowered ground-cherry			S3?				
Listera auriculata	auricled twayblade			S3	END	END	SC	MI: Habitat is restricted but relatively secure and unthreatened, may be more common than now known WI: Alluvial sandy shores of streams adjacent to Lake Superior, often under alder thickets
Listera borealis	northern twayblade			S2				
Listera convallarioides	broad-leaved twayblade				SPC	THR		WI: Moist woods and seeps along Lake Superior
Lithospermum canescens	hoary puccoon			S3?				
Littorella uniflora	American shore-grass				SPC	SC	SC	
Lonicera involucrata	fly honeysuckle					SC	THR	MI: More common in Canada and western states
Luzula parviflora	small-flowered wood-rush				SPC		THR	
Lycopodiella appressa	southern bog clubmoss						THR	
Malaxis paludosa	bog adder's-mouth			S1				
Melica smithii	Smith melic grass					END		WI: One known site
Mimulus glabratus var jamesii	James' monkey-flower							
Mimulus guttatus	common large monkeyflower						SC	
Mimulus moschatus	muskflower			S2?				
Moehringia macrophylla	large-leaved sandwort			S2	THR	END	THR	WI: Habitat requirements are not well understood; extremely rare
Muhlenbergia cuspidata	plains muhly						EXTR	
Muhlenbergia racemosa	upland wild timothy			S1				
Muhlenbergia uniflora	one flowered muhly				SPC			
Myriophyllum alterniflorum	alternate-flowered water milfoil						SC	

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		Can	US	ON	MN	WI	MI	Comments
Myriophyllum farwellii	Farwell's water-milfoil					SC	THR	
Najas gracillima	thread-like naiad				SPC			
Nuphar lutea ssp pumila	yellow cowlily						THR	
Nymphaea leibergii	small white water-lily				THR			
Nymphaea tetragona	pygmy water-lily						THR	MI: Greatest threat is water quality changes
Oenothera villosa	hairy evening-primrose			S2?				
Ophioglossum vulgatum	adder's-tongue					SC		
Oplopanax horridus	devil's-club			S1			THR	
Opuntia fragilis	brittle prickly-pear					THR	END	MI: Widespread in the west
Orobanche uniflora	one-flowered broomrape					SC		
Oryzopsis canadensis	Canada mountain-ricegrass					SC	THR	
Osmorhiza chilensis	Chilean sweet cicely				END	SC		
Osmorhiza depauperata	blunt-fruited sweet-cicely				SPC		THR	
Oxytropis splendens	showy locoweed			S3	END			
Oxytropis viscida var. viscida	stemless locoweed			S1	END?			
Panax quinquefolius	American ginseng					SC	THR	MI: Primary threat is digging of roots for export
Panicum leibergii var. Baldwinii	Baldwin's panic grass			S1S2				
Parnassia palustris	marsh grass-of-parnassus					THR	THR	
Pellaea atropurpurea	purple-stem cliff-brake					SC	THR	
Petasites sagittatus	arrow-leaved sweet-coltsfoot					THR	THR	WI: Low, wet, marshy, open ground
Phacelia franklinii	Franklin's phacelia			S2	SPC		THR	
Phleum alpinum	mountain timothy						EXTR	
Pinguicula vulgaris	common butterwort				SPC	END	SC	WI: Cool, open sandstone cliffs
Platanthera clavellata	alpine bistort				SPC			
Platanthera dilatata	leafy white orchis					SC		
Platanthera hookeri	hooker orchis					SC		
Platanthera macrophylla	large round-leaved orchid			S2		SC		WI: as var. of orbiculata
Platanthera orbiculata	large roundleaf orchid					SC		
Poa alpina	alpine bluegrass						THR	
Poa canbyi	Canby bluegrass			S1			END	

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		Can	US	ON	MN	WI	MI	Comments
Poa interior	inland bluegrass			S3?				
Poa paludigena	bog bluegrass						THR	
Poa wolfii	Wolf's bluegrass				SPC			
Polemonium occidentale ssp lacustre	Jacob's-ladder				END?	END		
Polygonella articulata	coast jointweed			S3				WI: not listed, maybe should be
Polygonum viviparum	alpine bistort				SPC		THR	
Polystichum braunii	Braun's holly-fern			S3	END	THR		WI: Sensitive to logging activity
Potamogeton confervoides	algae-like pondweed			S2		THR	THR	MI: Susceptible and possibly declining in areas where habitat degradation is increasing through lakeshore development
Potentilla gracilis	cinquefoil			S2				
Potentilla hippiana	cinquefoil			S1				
Potentilla multifida	cinquefoil			S2				
Potentilla pensylvanica	Pennsylvania cinquefoil						THR	
Potentilla rivalis	cinquefoil			SH				
Primula mistassinica	bird's-eye primrose					SC		
Pterospora andromedea	giant pinedrops			S2		END	THR	
Pyrola minor	small shinleaf				SPC	END		
Ranunculus cymbalaria	seaside crowfoot					THR		WI: More along MI than Superior
Ranunculus gmelinii var hookeri	small yellow water-crowfoot					END		
Ranunculus lapponicus	Lapland buttercup				SPC	SC		
Ranunculus macounii	Macoun buttercup						THR	MI: Abundant in Canada
Ranunculus rhomboideus	prairie buttercup						THR	MI: Range would seem to justify G5 rank, more info needed
Rhynchospora fusca	brown beakrush				SPC	SC		
Ribes hudsonianum	northern black currant					SC		
Ribes oxyacanthoides	Canada gooseberry					THR	SC	WI: Requires a cool micro-habitat
Rubus chamaemorus	cloudberry				THR			
Sagina nodosa	knotted pearlwort				END		THR	
Sagittaria graminea var. Cristata	crested arrow-head			S3				
Salix pellita	satiny willow				SPC	END	SC	

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		Can	US	ON	MN	WI	MI	Comments
Salix planifolia	tea-leaved willow					THR	THR	
Saxifraga cernua	nodding saxifrage				END			
Saxifraga paniculata	white mountain-saxifrage				THR		THR	
Saxifraga tricuspidata	prickly saxifrage						THR	
Schistostega pennata	luminous moss				END			
Scirpus clintonii	Clinton bulrush			S2	SPC		THR	MI: Secure only in part of its range, need more info
Scirpus heterochaetus	slender bulrush			S2				WI: not listed, maybe should be
Scirpus torreyi	Torrey's bulrush					SC	SC	
Selaginella densa	prairie spikemoss			S2				
Selaginella selaginoides	northern spikemoss				END			
Senecio congestus	marsh ragwort					SC		
Senecio eremophilus	groundsel			S1				
Senecio indecorus	plains ragwort				SPC	THR	THR	
Senecio obovatus	roundleaf ragwort			S3				
Senecio plattensis	prairie ragwort			S2S3				WI: not listed, probably should be
Sisyrinchium strictum	blue-eyed grass						THR	
Solidago decumbens	reclining goldenrod						END	
Solidago houghtonii	Houghton's goldenrod		THR				END	
Solidago lepida	western goldenrod							
Solidago missouriensis	Missouri goldenrod			S2				
Solidago rigida ssp. Rigida	stiff goldenrod			S3				
Solidago simplex var nana	sticky goldenrod						SC	
Sparganium glomeratum	northern bur-reed				SPC	THR		
Sparganium multipedunculatum	many-stalked burweed			S1				
Stellaria crassifolia	fleshy stitchwort						THR	MI: Circumboreal species
Stellaria longipes	long-stalked stitchwort						SC	
Stipa comata	needle-and-thread			S1				
Subularia aquatica	water awlwort			S3?	THR		END	
Tanacetum huronense	Lake Huron tansy						THR	
Thalictrum revolutum	waxleaf meadowrue					SC	THR	
Thalictrum venulosum	veined meadowrue					SC		

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		Can	US	ON	MN	WI	MI	Comments
Thalictrum venulosum var confine	boundary meadow-rue						THR?	
Tofieldia pusilla	Scotch false-asphodel				END		THR	
Tomentypnum falcifolium	a moss				SPC			
Torreyochloa pallida	Torrey's manna-grass				SPC			
Triglochin maritimum	common bog arrow-grass					SC		
Triglochin palustre	slender bog arrow-grass					SC		
Trisetum melicoides	purple false oats			S3S4		END		
Trisetum spicatum	narrow false oats					THR	SC	WI: Only in Ashland and Bayfield Counties
Tsuga canadensis	eastern hemlock				SPC			
Utricularia resupinata	northeastern bladderwort					SC		
Vaccinium cespitosum	dwarf huckleberry					END	THR	
Vaccinium membranaceum	mountain bilberry			S1				
Vaccinium ovalifolium	blue bilberry			S2				
Vaccinium uliginosum	alpine bilberry				THR		THR	
Vaccinium vitis-idaea	mountain-cranberry						END	
Vaccinium vitis-idaea ssp minus	mountain cranberry					END		WI: Wisconsin is at very southern edge of range
Valeriana uliginosa	marsh valerian					THR		WI: Openings in northern wet forests
Viburnum edule	squashberry					END	THR	
Viola epipsila	northern marsh violet			S3			EXTR	
Viola lanceolata	lance-leaved violet				THR			
Viola novae-angliae	New England violet			S2S3				
Waldsteinia fragariodes	barren strawberry				SPC			
Woodsia alpina	northern woodsia			S2	SPC		THR	MI: Highly fragmented range
Woodsia glabella	smooth woodsia			S3	THR			
Woodsia obtusa	blunt-lobed woodsia						THR	
Woodsia oregana	western woodsia			S3		SC		
Woodsia scopulina	rocky mountain woodsia			S3	THR			
Xyris montana	montane yellow-eyed grass				SPC			
Zizia aptera	heartleaf alexanders			S1				

ADDENDUM 6-B
RARE COMMUNITY ASSOCIATIONS IN THE LAKE SUPERIOR BASIN

(Global rank of G3 or lower). (Mary Harkness, Karen Cieminski, Sharron Nelson, Eric Epstein pers. comm., Soule 1993) .

Non-Tidal Wetlands

Fens

Northern (Laurentian) Fens

Northern (Laurentian) Graminoid Fens

		Global Rank	*Distribution*	*ON*	*MN*	*WI*	*MI*
Northern Poor Fen	Carex lasiocarpa - Carex oligosperma / Sphagnum spp. Herbaceous Vegetation	G3G4	Widespread	X		X	

Northern (Laurentian) Patterned Peatlands

		Global Rank	*Distribution*	*ON*	*MN*	*WI*	*MI*
Patterned Rich Fen	Pentaphylloides floribunda - Betula pumila / Carex lasiocarpa Patterned Herbaceous Vegetation	G3G4	Peripheral	X			

Northern (Laurentian) Shrub Fens

		Global Rank	*Distribution*	*ON*	*MN*	*WI*	*MI*
Great Lakes Leatherleaf Intermittent Wetland	Chamaedaphne calyculata / Carex oligosperma / Sphagnum spp.	G3Q	Widespread	X		X	

Swamps

Midwestern Swamps and Flatwoods

Midwestern Shrub Swamps

		Global Rank	*Distribution*	*ON*	*MN*	*WI*	*MI*
Dogwood - Mixed Willow Shrub Meadow	Cornus sericea - Salix (bebbiana, discolor, petiolaris) / Calamagrostis stricta Shrubland	G3G4		X		X	

Northern (Laurentian) Swamps

Northern (Laurentian) Conifer-(Hardwood) Swamps

		Global Rank	*Distribution*	*ON*	*MN*	*WI*	*MI*
White Cedar Seepage Swamp	Thuja occidentalis - (Larix laricina) Seepage Forest	G3G4	Widespread	X		X	

		Global Rank	Distribution	ON	MN	WI	MI
Hemlock - Yellow Birch Wet-mesic Forest	Tsuga canadensis - Betula alleghaniensis Saturated Forest	G3	Widespread			X	

Woody Floodplains/Riparian Zones

Northern (Laurentian) Wooded Floodplains

Northern (Laurentian) Wooded Floodplains

		Global Rank	Distribution	ON	MN	WI	MI
Northern Ash - Elm - Hackberry Floodplain Forest	Fraxinus pennsylvanica - Ulmus americana - (Celtis occidentalis, Tilia americana) Northern Forest	G3G4Q	Widespread			X	

Uplands

Beaches

Great Lakes Beaches

Great Lakes Beaches

		Global Rank	Distribution	ON	MN	WI	MI
Great Lakes Beach	Cakile edentula Great Lakes Shore Sparse Vegetation	G3?	Endemic			X	

Cliffs, Buttes & Bluffs

Great Lakes Cliffs

Great Lakes Cliffs

		Global Rank	Distribution	ON	MN	WI	MI
Great Lakes Sandstone Cliff	Sandstone Cliff Great Lakes Sparse Vegetation	G4G5	Endemic				X
Great Lakes Open Alkaline Cliff	Open Great Lakes Alkaline Cliff Sparse Vegetation	G4G5	Endemic				X
Great Lakes Basalt/Diabase Cliff	Basalt/Diabase Great Lakes Cliff Sparse Vegetation	G?	Widespread				X

Northern (Laurentian) Cliffs & Bluffs

Northern (Laurentian) Cliffs & Bluffs

		Global Rank	Distribution	ON	MN	WI	MI
White Cedar Cliff Woodland	Thuja occidentalis Cliff Woodland	G2Q	Widespread			X	

Dunes

		Global Rank	*Distribution*	*ON*	*MN*	*WI*	*MI*

Great Lakes Dunes

Great Lakes Herbaceous Dunes

		Global Rank	*Distribution*	*ON*	*MN*	*WI*	*MI*
Great Lakes Beachgrass Dune	Ammophila breviligulata - (Schizachyrium scoparium) Herbaceous Vegetation	G3G5	Endemic	X		X	X

Great Lakes Wooded Dunes

		Global Rank	*Distribution*	*ON*	*MN*	*WI*	*MI*
Great Lakes Dune Pine Forest	Pinus banksiana - Pinus resinosa - Pinus strobus Dune Forest	G3Q	Endemic			X	
Great Lakes Pine Barrens	Pinus banksiana - (Pinus resinosa) - Pinus strobus / Juniperus horizontalis Wooded Herbaceous Vegetation	G2	Endemic			X	

Interdunal Wetlands

		Global Rank	*Distribution*	*ON*	*MN*	*WI*	*MI*
Interdunal Wetland	Pentaphylloides floribunda / Cladium mariscoides - Juncus balticus - (Rhynchospora capillacea) Herbaceous Vegetation	G3?	Endemic			X	X

Forests & Woodlands

Northern (Laurentian) Forests & Woodlands

Northern (Laurentian) Dry Conifer-(Hardwood) Forests & Woodlands

		Global Rank	*Distribution*	*ON*	*MN*	*WI*	*MI*
White Pine / Blueberry Dry-mesic Forest	Pinus strobus / Vaccinium spp. Forest	G3G4	Widespread	X		X	
White Pine / Mountain Maple Mesic Forest	Pinus strobus / Acer spicatum - Corylus cornuta Forest	G3G4	Widespread	X	X		
White Pine - Red Oak Forest	Pinus strobus - (Pinus resinosa) - Quercus rubra Forest	G3	Widespread			X	
Red Pine / Blueberry Dry Forest	Pinus resinosa / Vaccinium spp. Forest	G3	Widespread	X	X	X	
Jack Pine - Red Pine / Scrub Oak Woodland	Pinus banksiana - Pinus resinosa / Quercus ellipsoidalis Woodland	G3G4	Widespread			X	

Northern (Laurentian) Hardwood Forests

		Global Rank	*Distribution*	*ON*	*MN*	*WI*	*MI*
Northern Maple - Basswood Forest	Acer saccharum - Tilia americana / Ostrya virginiana / Lonicera canadensis Forest	G3?	Peripheral			X	

		Global Rank	Distribution	ON	MN	WI	MI
Maple - Yellow Birch Northern Hardwoods Forest	Acer saccharum - Betula alleghaniensis - (Tilia americana) Forest	G3G4	Widespread	X	X	X	

Northern (Laurentian) Mesic Conifer-(Hardwood) Forests

		Global Rank	Distribution	ON	MN	WI	MI
White Cedar - (Hemlock) Mesic Forest	Thuja occidentalis - (Betula alleghaniensis, Tsuga canadensis) Forest	G3?	Widespread			X	
Great Lakes White Pine - Hemlock Forest	Pinus strobus - Tsuga canadensis Great Lakes Forest	G3?	Widespread			X	
Northern White Cedar - Yellow Birch	Thuja occidentalis - Betula alleghaniensis Forest	G2Q	Widespread		X	X	
Hemlock Mesic Forest	Tsuga canadensis - (Betula alleghaniensis) Forest	G3G4	Widespread			X	

Prairies/Grasslands

Midwestern Tallgrass Prairies

Midwestern Sand/Gravel Prairies

		Global Rank	Distribution	ON	MN	WI	MI
Fescue Grassland	Festuca hallii	?	Peripheral	X			

Rocky Flats (Glades,Rock Barrens,Rock Outcrops,Alvars)

Northern (Laurentian) Barrens/Rock Outcrops

Northern (Laurentian) Shrub Rock Outcrops/Barrens

		Global Rank	Distribution	ON	MN	WI	MI
Common Juniper Rocky Krummholz	Juniperus communis - (Quercus rubra) / Juniperus horizontalis - Arctostaphylos uva-ursi Shrubland	G3G4	Limited	X		X	

Northern (Laurentian) Treed Rock Outcrops/Barrens

		Global Rank	Distribution	ON	MN	WI	MI
White Pine - Oak Acid Bedrock Glade	Pinus strobus - Quercus rubra / Danthonia spicata Acid Bedrock Wooded Herbaceous Vegetation	G3Q	Widespread			X	

Rocky Shores

Great Lakes Rocky Shores

		Global Rank	Distribution	ON	MN	WI	MI
Great Lakes Rocky Shores							
Great Lakes Arctic-Alpine Basic Bedrock Shoreline	Great Lakes Bedrock Lakeshore	?	Endemic	X			
Great Lakes Non-Alkaline Cobble/Gravel Shore	Non-alkaline Cobble - Gravel Great Lakes Shore Sparse Vegetation	G3G4	Endemic	X	X	X	
Great Lakes Sandstone Bedrock Shore	Sandstone Bedrock Great Lakes Shore Sparse Vegetation	G3G4	Endemic			X	

Midwestern Rivers Rocky Shores

		Global Rank	Distribution	ON	MN	WI	MI
Midwestern Rivers Rocky Shores							
River Cobble-Gravel Shore	Cobble - Gravel River Shore Sparse	G3?	Widespread			X	

Savannas (Barrens) & Woodlands (In Part)

Midwestern Oak Savannas & Woodlands

		Global Rank	Distribution	ON	MN	WI	MI
Midwestern Oak Savannas & Woodlands							
Northern Oak Barrens	Quercus macrocarpa - (Quercus ellipsoidalis) / Schizachyrium scoparium - Koeleria macrantha Wooded Herbaceous	G2				X	
Bur Oak / Saskatoon Berry Woodland	Quercus macrocarpon - Amelanchier spp Woodland	G2	Peripheral	X			

Northern (Laurentian) Pine Barrens

		Global Rank	Distribution	ON	MN	WI	MI
Northern (Laurentian) Pine Barrens							
Jack Pine / Prairie Forbs Barrens	Pinus banksiana - (Quercus ellipsoidalis) / Schizachyrium scoparium - Prairie Forbs Wooded Herbaceous Vegetation	G2	Limited			X	
Jack Pine - Red Pine Barrens	Pinus banksiana - Pinus resinosa / Carex pensylvanica Wooded Herbaceous	G3G4	Widespread			X	

Talus

Northern (Laurentian) Talus

		Global Rank	Distribution	ON	MN	WI	MI
Northern (Laurentian) Talus							
Glaciere Talus Vegetation	Talus Overlying Persistent Ice Sparse	?	Limited	X			

ADDENDUM 6-C . HABITAT DATA FOR 65 LAKE SUPERIOR TRIBUTARIES IN ONTARIO (OMNR DATA).

Tributary	Gradient (m/km)	Length (km)	Drainage Area (ha)	Barrier	Distance from terminus (km)	Vertical Height (m)	Fish Species Inventory	Riparian Alterations	Erosion Problems	Lamprey Treatment	Habitat related limitations
Agawa River				falls		25	yes	channelization		TFM	
Aguasabon River				falls			yes			no	
Barrett River	27.1	7.3	3119		0.8		yes			no	
Batchewana River				falls			no				
Bennett Creek	24.3	16.5	3246.8	falls		25	yes		yes	TFM	
Big Carp River	18.9	16.5	3784.8	falls		40	yes		yes	TFM	Limited benthic production
Big Squaw Creek*											
Black River				power dam	8		yes	habitat enhancement		no	
Carp River	12.6	17.9	5255.3	falls			yes			TFM	
Chippewa River				falls			yes			TFM	
Clay River	58.4	2.6	438.6				yes			no	
Cold Water River	10.4	13.1	7272.5	falls	1		yes			no	
Cranberry Creek	11.9	12.1	3363.4				yes			removable weir	
Crazy Creek	40.4	4.6	493	falls	1.1		yes			no	
Cypress River	7	37	1596	falls		6	no			TFM	Low summer flows
Deadhorse Creek*	6.4	19.4	5311.6	falls			yes				Siltation
Dog River	3.1	82.4	119400	falls	2.5		yes			TFM	
Dublin Creek	23.3	12.4	2254	beaver dam			no				Low summer flows
East Davignon Creek	25.7	13.6	2008	falls	9	30	yes	Siltation, pollution, low summer flow, BOD, high temperatures		TFM	Siltation, pollution, low summer flow, BOD, high temperatures

ADDENDUM 6-C . HABITAT DATA FOR 65 LAKE SUPERIOR TRIBUTARIES IN ONTARIO (OMNR DATA).

Tributary	Gradient (m/km)	Length (km)	Drainage Area (ha)	Barrier	Distance from terminus (km)	Vertical Height (m)	Fish Species Inventory	Riparian Alterations	Erosion Problems	Lamprey Treatment	Habitat related limitations
Emogene River	19.7	8.5	1725	beaver dam	1.4	1	yes			no	
Firehill Creek*											
Fisherman's Cove Creek	29.3	5.2	848	beaver dam	0.7	1	yes			no	
Frater Creek							yes			no	
Goulais River				1			yes			TFM	
June Creek	17.8	4	1738.5				yes			no	
Laughing Brook Creek	83.5	2.5	1403.6				yes			no	
Little Carp River	22.4	15.6	2253.9	falls	8.77	30	yes		yes	TFM	
Little Cypress River	27.2	6.2	1120	falls		8	yes	habitat enhancement	yes	no	Low summer flows, High temps, barrier
Little Gravel River*											
Little Pic River	1.1	157.9	118219	falls			yes			TFM	Siltation
Little Squaw Creek*											
Little Steel River							yes			no	Low summer flows
McInnes Creek	21.2	4.3	617.3				no			no	Low summer flows
McIntyre Creek*											
McIntyre River*											
McKellar Creek*											
McLean's Creek*											
McVicar Creek*											
Michipicoten River	1.7	127.5	708994.1	power dam	16.6		yes			TFM, Bayer	Water fluctuations
Mink Creek*											
Montreal River				power			no			no	

ADDENDUM 6-C . HABITAT DATA FOR 65 LAKE SUPERIOR TRIBUTARIES IN ONTARIO (OMNR DATA).

Tributary	Gradient (m/km)	Length (km)	Drainage Area (ha)	Barrier	Distance from terminus (km)	Vertical Height (m)	Fish Species Inventory	Riparian Alterations	Erosion Problems	Lamprey Treatment	Habitat related limitations
				dam							
Neebing River*											
Nicol's Cove Creek	37.3	5.3	350	beaver dam	1.5		yes			no	
North Current River											
North Swallow River	17.9	17	5473	falls	0.2		yes			no	
North Trout Creek*											
Oiseau Creek	16.4	11.1	2998	falls	2.8		yes		yes	no	channelized sand streambed
Old Woman River							yes			no	
Portage Creek*											
Pukaskwa River	3.9	81.8	108600	falls	0.7		yes			no	
Robertson Creek	9.1	8.6	5248.7				yes			no	
Ruby Creek*											
Sand River							yes			TFM, Bayer	
Simons Harbour Creek	41.1	3.7	382	power dam	0.6		yes			no	
South Trout Creek*											
Speckled Trout Creek	17.3	12.8	4385.7				yes			no	
Stillwater Creek*											
Stokely Creek	17.3	11.8	5102.7	falls	9.6		yes	bank stabilization	yes	TFM, permanent weir	
Swallow River	11.7	33.8	12878	falls	1.2		yes			no	
Tagouche Creek	10.3	23.6	5935	power dam	1.4		yes			no	

ADDENDUM 6-C . HABITAT DATA FOR 65 LAKE SUPERIOR TRIBUTARIES IN ONTARIO (OMNR DATA).

Tributary	Gradient (m/km)	Length (km)	Drainage Area (ha)	Barrier	Distance from terminus (km)	Vertical Height (m)	Fish Species Inventory	Riparian Alterations	Erosion Problems	Lamprey Treatment	Habitat related limitations
Trout Creek							yes				
Unnamed Creek (Ozone/Jackfish)*											
Wawa Creek	10.7	10		falls			yes			no	
West Davignon Creek	26.4	13.2	2150.2	falls	7.75		yes			TFM	
Whitesand River*											

* habitat survey completed in 1998, but data not yet unavailable

ADDENDUM 6-D IMPORTANT HABITAT AREAS OF THE LAKE SUPERIOR BASIN

Site Code	Site Name	Site Significance	Ecological Criteria (see below for definitions)															
			E1	E2	E3	E4	E5	E6	C1	C2	C3	C4	S1	S2	S3	S4	S5	S6
MI-001	Laughing Whitefish Falls	Mesic Northern Forest, rare plant habitat										X	X					
MI-002	Rock River Canyon Wildernes Area	Moist non-acid cliff, mesic northern forest, geographical features, rare plant and animal habitats							X			X	X					
MI-003	Canyon Falls	Rare plant habitat, geographical feature											X					
MI-004	Whitefish Point	Rare plant and animal habitat											X		X	X		
MI-005	Long Lake	Rare plant and animal habitats, proposed wilderness											X	X				
MI-006	Silver Mountain	Rare plant habitat, geographical feature											X					
MI-007	Agate Harbor	Rare plant habitat											X					
MI-008	Caribou Island	Rare plant habitat											X					
MI-009	Cat Harbor	Hardwood-conifer swamp, rare plant habitat										X	X					
MI-010	Cliff Mine	Rare plant habitat											X					
MI-011	Davidson Island	Rare plant and animal habitat											X					
MI-012	Edwards Island	Rare plant habitat											X					
MI-013	Estivant Pines	Dry-mesic northern forest										X						
MI-014	Fort Wilkins	Rare plant and animal habitats											X					
MI-015	Hat Island	Rare plant and animal habitats											X					
MI-016	Mount Brockway	Rare plant habitat											X					
MI-017	Barclay Lake	Bog, dry northern forest, rare plant habitat										X	X					
MI-018	Barfield Lakes	Bog, dry northern forest, rich conifer swamp, mesic northern forest										X						
MI-019	Beavertown Lakes	Dry northern forest, hardwood-conifer swamp, rich conifer swamp, muskeg, dry-mesic northern forest										X						
MI-020	Blind Sucker River	Rare plant and animal habitat											X					
MI-021	Crisp Point	Rare plant and animal habitat				X							X					
MI-022	Deer Park	Rare plant and animal habitat				X							X					
MI-023	Little Lake	Rare plant and animal habitat											X					
MI-024	McMahon Lake	Patterned fen, rare plant habitat										X	X					
MI-025	Swamp Lakes	Intermittent wetland, dry-mesic northern forest, rare plant habitat										X	X					
MI-026	Dukes RNA	Rich conifer swamp, mesic northern forest			X							X						
MI-027	Mulligan Creek	Rare plant habitat											X					

ADDENDUM 6-D IMPORTANT HABITAT AREAS OF THE LAKE SUPERIOR BASIN

MI-028	Tahquamenon Bay	Rare plant habitat, rare animal habitat, wooded dune and swale complex				X			X				X					
MI-029	Vermillion	Lake Superior beach community, rare plant and animal habitat				X							X			X		
MI-030	Two-Hearted River	Representative landscape comlex, old growth red/white pine forest, old growth cedar forest, hemlock and white pine forest, rare plant habitat, migrant bird habitat, relatively undisturbed wetland communities, coastal plain marsh, patterened fen, muskeg, bog	X		X	X	X	X	X	X		X	X		X		X	
MI-031	Grand Marais	Rare plant and animal habitats											X					
MI-032	Grand Sable Dunes	Perched dunes, open dunes, geologic feature, rare plant habitat		X			X	X	X	X	X		X				X	
MI-033	Grand Island	Great Lakes marsh, mesic northern forest, rare plant and animal habitat				X	X		X				X	X				
MI-034	Au Train	Large Great Lakes marsh, fresh water estuary, high biodiversity	X			X	X	X				X	X		X	X		
MI-035	Presque Isle	Bedrock beach, dry-mesic northern forest, rare plant habitat, geographical features				X			X				X					
MI-036	McCormick	Mesic northern forest, rare plant habitat										X	X					
MI-037	Lake Independence	Great Lakes marsh, geologic features, rare animal habitat, high biodiversity				X	X		X	X			X					
MI-038	Huron Mountain	Rare plant and animal habitat, mesic northern forest, dry-mesic northern forest, bedrock glade	X	X	X		X						X			X		
MI-039	Pequaming Marsh	Great Lakes marsh, rare animal habitat, geologic feature				X							X					
MI-040	Portage River	Great Lakes marsh, geologic features, rare animal habitat				X	X							X		X		
MI-041	Keweenaw Peninsula	Rare plant and animal habitat geologic features, high biodiversity	X			X	X	X	X	X	X		X					
MI-042	Porcupine Mountains	Mesic Northern Forest, rare plant and animal habitat	X	X	X	X	X	X	X	X		X	X		X			
MI-043	Isle Royale	Rare plant and animal habitat, fish spawning habitat, colonial waterbird habitats	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
MI-044	Sylvania Wilderness Area	Large area of undisturbed presettlement vegetation, old growth forest, pristine lakes, diverse habitat types, rare plant and animal habitat.	X	X	X		X	X				X	X					
MI-045	Delerium Wilderness Area	Representative natural plant communities	X	X	X													

ADDENDUM 6-D IMPORTANT HABITAT AREAS OF THE LAKE SUPERIOR BASIN

MI-046	Pictured Rocks National Park	Rare plant habitat, geomorphic features	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
MI-047	Tahquamenon Falls State Park	Wooded dune and swale complex, rare plant and animal habitat							X			X	X					
MN-001	Agate Bay	Colonial waterbird nesting, waterfowl concentrations													X	X		
MN-002	Alborn Fen	Poor Fen, sedge subtype, rare plant habitat							X			X	X					
MN-003	Alton Lake	Rare animal habitat											X					
MN-004	Amenda Creek	Northern Hardwood Forest, Upland White Cedar Forest			X				X			X						
MN-005	Arlberg Bog	Rare plant habitat											X					
MN-006	Grand Marais Point	Arctic disjunct plant community, rare plant habitat, geologic features							X	X			X					
MN-007	Beaver Bay	Waterbird concetrations, Upland White Cedar Forest			X									X				
MN-008	Beaver Island	Arctic disjunct plant community, rare plant habitat, colonial waterbird nesting habitat							X	X			X			X		
MN-009	Black Lake Bog SNA	Black ash swamp, fen, forested bog, and open bog plant communities, rare plant habitat.	X				X			X		X						
MN-010	Blackfoot Lake Peatland	Poor Fen, Sedge subtype, rare plant habitat							X				X					
MN-011	Big Bay	Geologic Feature							X			X						
MN-013	Boundry Waters Canoe Area	Rare plant and animal habitat, large representative ecosysems, geologic features	X	X	X		X	X	X			X	X	X	X	X	X	
MN-014	Burlington Bay	Colonial Waterbirds, waterfowl concentrations													X	X		
MN-015	Butterwort Cliffs SNA	Rock shore community, aspen-birch forest, rare plant habitat, colonial waterbird habitat				X			X	X			X			X		
MN-017	Cannonball Bay	Arctic disjunct plant community, rare plant habitat							X	X			X					
MN-018	Caribou Falls WMA	Anadromous fish habitat, deer concetration area												X				
MN-019	Cascade River State Park	Arctic disjunct plant community, rare plant habitat							X	X		X	X					
MN-020	Cathedral Grove	Great Lakes pine forest, old growth forest			X					X	X	X						
MN-024	Cloquet River Macrosite	Rare animal habitat											X			X		
MN-025	Crow Creek Bluff	Rare animal habitat							X				X			X		
MN-026	Deronda Bay and Red Rock	Rare plant habitat, geologic feature				X			X				X					
MN-028	Devil Track Lake	Rare animal habitat											X					
MN-029	Duluth 8	Rare animal habitat								X			X			X		

ADDENDUM 6-D IMPORTANT HABITAT AREAS OF THE LAKE SUPERIOR BASIN

MN-030	Flood Bay	Colonial waterbird nesting habitat, shorebird migratory habitat, geomorphic feature													X	X		
MN-031	Five Mile Rock	Colonial waterbird nesting habitat, geologic feature														X		
MN-034	George H. Crosby Manitou State Park	Northern hardwood forest, upland white cedar forest, rare animal habitat, rare plant habitat, anadromous fish habitat	X		X	X		X				X	X	X	X	X		
MN-035	Good Harbor Bay	Arctic disjunct plant community, rare plant habitat, geologic feature				X			X			X	X					
MN-036	Gooseberry Falls State Park	Conifer, aspen and birch forests, fish spawning habitat, rare plant and animal habitat				X			X	X			X			X		
MN-037	Grand Marais Fen	Poor fen, sedge subtype				X			X			X						
MN-038	Grand Portage 4	Rare plant community								X			X					
MN-039	Grand Portage State Park	Rare plant habitat								X			X					
MN-040	Hat Point Area	Representative forest ecosystems, coastal shore communities, important natural/cultural resource				X	X	X	X			X			X			
MN-041	Heartbreak Creek	Northern hardwood-conifer forest, yellow birch-white cedar subtype, upland white cedar forest	X		X							X						
MN-042	Hollow Rock	Geomorphic feature (sea arch)							X									
MN-043	Holyoke	Northern hardwood forest				X						X				X		
MN-044	Hornby Lake	Rare plant habitat											X					
MN-045	Horseshoe Bay	Gomorphic feature (raised beach)							X									
MN-046	Hovland Woods SNA	Large old growth forest complex with bogs, swamps, lake in the landscape, rare plant and animal habitat			X		X					X	X					
MN-048	Jay Cooke State Park	Rare plant habitat, northern hardwood forest										X	X					
MN-050	Judge C. R. Magney State Park	Old growth white pine forest, rare plant habitat, gemorphic features, anadromous fish habitat			X			X					X		X	X		
MN-051	Kodonce Creek	Rare plant community							X				X					
MN-052	Kennedy Creek	Rare animal habitat											X					
MN-053	Knife River	Rare plant habitat, anadromous fish habitat, geomorphic features											X	X	X	X		
MN-054	Lafayette Bluff and Encampment Island	Colonial waterbird nesting habitat														X		
MN-055	Lake Agnes Hardwoods	Northern hardwood forest, rare plant habitat										X	X		X			
MN-056	Lake Superior Highlands	Extensive natural communities and high biodiversity, rare plant and animal habitat	X	X	X	X	X	X	X			X	X	X	X	X	X	

ADDENDUM 6-D IMPORTANT HABITAT AREAS OF THE LAKE SUPERIOR BASIN

MN-057	Lester Park Waterworks	Rare plant habitat								X			X					
MN-058	LeVeaux WMA	Representative natural plant communities, rare animal habitat										X	X					
MN-059	Lighthouse Point	Rare plant habitat								X			X					
MN-060	Little Marais	Rare animal habitat, colonial waterbird nesting habitat											X			X		
MN-061	Ludwig	Old growth Northern Hardwood forest, rare plant habitat	X		X		X	X		X		X	X					
MN-062	Lutsen SNA	Old growth Northern Hardwood forest and upland white cedar forest	X		X		X			X		X						
MN-064	Magney Hardwoods Forest	Old growth mixed hardwoods/conifer forest and northern hardwoods forest; rare plant habitat	X		X		X						X					
MN-065	Manitou River	Fish spawning habitat, rare plant habitat											X			X		
MN-067	Marble Lake Lookout Tower	Northern Hardwoods forest, rare plant habitat	X				X						X					
MN-068	Mineral Center Maple Ridge	Northern Hardwood forest, rare plant habitat	X		X		X						X					
MN-069	Minnesota Point	Rare plant habitat, unique geomorphic formation, old growth pine forest		X	X	X	X	X	X	X		X	X		X			
MN-071	Moose Fence Cedars	Upland white cedar forest			X		X					X						
MN-072	Moose Mountain SNA	Old growth Northern Hardwoods forest, rare plant habitat			X		X					X						
MN-075	Nickerson 30	Rare plant habitat											X					
MN-076	Normanna 18	Rare animal habitat											X					
MN-077	Oberg Mountain Hardwoods	Northern harwood forest, rare plnat habitat			X							X	X					
MN-078	Onion River Hardwoods	Northern hardwood forest, rare plant habitat			X					X		X	X					
MN-079	Paradise Beach	Coastal wetland, tamarack swamp, colonial waterbird nesting habitat, waterbird concentrations, geologic formations				X	X	X	X			X				X		
MN-080	Pearl Beach Hardwoods	Northern hardwood forest										X						
MN-081	Poplar River Cedars	Old growth upland white cedar forest			X			X		X								
MN-082	Poplar River	Fish spawning habitat													X			
MN-086a	Interstate Island	Rare animal habitat, colonial waterbird nesting habitat											X					
MN-086b	Hearding Island	Open dunes, representative natural plant community							X			X						

ADDENDUM 6-D IMPORTANT HABITAT AREAS OF THE LAKE SUPERIOR BASIN

MN-086d	Spirit Lake Point	Great Lakes marsh, migaratory wildlife habitat	X			X		X				X		X	X	X		
MN-086e	Mud Lake	Great Lakes marsh, migaratory wildlife habitat				X		X						X	X	X		
MN-086f	Fond Du Lac	Great Lakes marsh, migaratory wildlife habitat				X		X						X	X			
MN-086g	Grassy Point	Great Lakes wetland complex				X		X										
MN-086h	Bong Bridge	Rare animal habitat											X					
MN-086i	Swamp Lake	Rare animal habitat													X	X		
MN-086j	St. Louis Estuary	Great Lakes freshwater estuary, rare plant and animal habitat, colonial waterbird nesting habitat	X	X		X	X	X		X	X	X	X	X	X	X		
MN-087	Sand Lake Peatland	Large patterned peatland, significant bog and fen features, rare plant habitat, rare animal habitat, geological processes	X	X			X	X				X	X					
MN-088	Schroeder RNA	Northern hardwood forest, rare plant habitat										X	X					
MN-089	Soo Line	Northern hardwood forest, rare plant habitat										X	X					
MN-090	South Fowl Lake	Rare plant habitat							X				X					
MN-091	South Lutsen	Rare plant and animal habitat											X					
MN-092	Split Rock Lighthouse State Park	Rare plant and animal habitats, colonial waterbird nesting habitat, geomorphic feature, waterbird concentrations											X			X		
MN-093	Spring Beauty Hardwoods SNA	Old growth northern hardwood forest, rare plant habitat	X		X								X					
MN-094	Stony Point	Rare plant habitat, arctic disjunct plant community, waterbird concentrations				X			X				X					
MN-095	Sugar Loaf Point SNA	Coastal wetland restoration project, rare plant habitat, geologic features				X			X			X	X					
MN-097	Susie Islands	Arctic-disjunct plant community, rare animal habitat	X			X	X	X	X			X	X	X	X	X		
MN-098	Swamp River Bog	Rare plant communities, old growth forest, rare plant habitat, rare animal habitat, waterbird concentrations	X	X	X		X	X				X	X					
MN-099	Temperance River State Park	Rare plant habitat, arctic disjunct plant populations, unusual geomorphic feature				X			X	X			X					
MN-100	Tettegouche State Park	Lake Superior pebble and bedrock beaches, exposed cliffs, Northern Hardwood-Conifer Forest, Northern Oak Forest, Upland White Cedar Forest	X	X	X	X	X	X	X	X		X	X		X	X		
MN-101	Tikander	Rare animal habitat, rare plant habitat, colonial waterbird nesting habitat											X			X		
MN-102	Tofte Town Park	Arctic and alpine disjunct plant habitat							X	X			X					
MN-103	Watab Lake Cliffs	Rare plant habitat											X					
MN-104	Wanless Lake Cedars	Old growth white cedar swamp			X							X						

ADDENDUM 6-D IMPORTANT HABITAT AREAS OF THE LAKE SUPERIOR BASIN

MN-105	Wolf Ridge	Rare animal habitat											X					
MN-106	Wringer Lake Hardwods	Northern hardwood forest, rare plant habitat										X	X					
MN-107	Yellow Birch	Norhtern hardwood forest, rare plant habitat										X	X					
MN-108	Burntside Island SNA	forested bedrock islands, old growth Great Lakes pine forest			X		X					X						
MN-109	Cross River State Park	Northern hardwoods forest, rare plant habitat										X	X					
MN-110	Devils Track Falls State Park	Rare plant habiat											X					
MN-111	Hemlock Ravine SNA	Rare plant habitat, old growth northern hardwoods, white pine, and eastern hemlock forest			X							X	X					
MN-112	Kodonce River State Park	Rare plant habitat											X					
MN-113	Ladies Tresses Swamp SNA	Lowland conifer forest dominated by mature white cedar, black ash, and black spruce, rare plant habitat							X			X	X					
MN-114	Savanna Portage State Park	Northern hardwood forest	X		X			X										
MN-115	Tettegouche State Park	Northern hardwood forest, Northern hardwood-conifer forest, old growth white cedar forest, complex of forested highlands, wetlands, streams and lakes with high biodiversity, Shoreline cliffs, rare animal habitat	X		X	X	X	X				X	X			X		
MN-116	Wawina Peatland SNA	Large peatland complex including ovoid island patterns, featureless water track, raised bog, crested raised bog	X	X	X		X	X	X			X						
ON-001	Michipicoten Corridor	Habitat for rare plants(arctic disjuncts) and animals; rocky outcrops and shallow soils with acid sensitivity	X			X		X	X			X	X	X	X	X	X	
ON-003	Algoma highlands	Habitat for endangered species, old growth pine forest	X		X					X			X	X			X	
ON-004	Gravel River falls	Fish spawning area											X	X		X	X	
ON-005	Batchawana Island	Coasta wetland; rare animal habitat, migratory bird habitat				X							X	X	X		X	
ON-006	Batchawana River	Fish spawning area														X		
ON-007	Batchewana Bay	Staging area and brood habitat for migratory waterfowl					X								X		X	
ON-008	Beatty and Sturdee Coves	Colonial water bird nesting area														X		
ON-009	Big Duck Creek	Fish spawning habitat in Big Duck Creek; fish habitat												X		X		
ON-011	Black Bay Peninsula	High biodiversity value, relatively undisturbed habitat, significant wetland	X				X	X				X						

ADDENDUM 6-D IMPORTANT HABITAT AREAS OF THE LAKE SUPERIOR BASIN

ON-013	Black Sturgeon River, Split Rapids	Spawning area and previous spawning area for fish					X						X	X		X	X	
ON-014	Blackbird Creek	Fish habitat (brook trout)														X		
ON-015	Bojack and Bone	Nesting site for water birds															X	
ON-016	Caldwell Lake	Wetland; rare plant and animal habitat					X		X				X	X				
ON-017	Cat Islands	Nesting site for colonial water birds														X		
ON-018	Nicholl Island Causway	Spring and fall staging area for migratory birds													X	X		
ON-019	Chippewa River	Excellent moose habitat, little access										X						
ON-020	Clark Island	Historic rare animal habitat											X				X	
ON-021	Nipigon Bay Clay Banks	Historic fish spawning habitat											X			X		
ON-022	Cobinosh Island	Historic rare animal habitat											X				X	
ON-023	Cypress River	Fish spawning area											X			X		
ON-024	Deadman's Cove	Wetland, fen with rare plants					X						X				X	
ON-025	Dog River System	Fish spawning area (Dog R. strain of lake trout is one of few river-spawning populations); fish habitat; waterfowl breeding/staging, rare plant habitat					X					X	X	X	X	X		
ON-029	Dove Bay	Fish spawning area														X		
ON-030	Dublin Creek	Suspected fish spawning area											X			X		
ON-031	Eagle River	Fish habitat														X		
ON-033	Flowerpot Islands	Colonial water birds														X		
ON-034	Fluor Island	High biodiversity values				X	X											
ON-035	Wawa Fume Kill	High biodiversity values					X											
ON-037	Redsucker Cove	Fish spawning habitat																
ON-039	Golfcourse Creek	Fish spawning habitat														X		
ON-040	Goulais River Delta	Fish spawning area, rare species habitat				X	X	X						X		X		
ON-041	Goulais River	Fish spawning habitat											X			X		
ON-042	Gravel Beach	Fish spawning area														X		
ON-043	Green Island	Colonial water bird habitat														X		
ON-044	Harmony River	Fish spawning habitat (largest run of rainbow smelt in area) feeding area for heron														X		
ON-045	Hawkins Island	Colonial water bird habitat														X		
ON-046	Inside Islands of Nipigon Bay	Fish habitat; raptor habitat											X		X	X		

ADDENDUM 6-D IMPORTANT HABITAT AREAS OF THE LAKE SUPERIOR BASIN

ON-047	Jackfish Lake	Former fish spawning areas											X	X		X		
ON-048	Kama Bay West	Fish spawning area											X			X		
ON-049	Keifer Terminal Floodway	Coastal wetland; waterfowl staging area and brood rearing				X										X		
ON-050	King Mountain	High biodiversity value; old growth forest pockets; representative landscape			X		X					X						
ON-051	Lake Helen	Former fish spawning area														X		
ON-052	Leach Island	Rare animal habitat (unoccupied)											X					
ON-054	Magnecon Pond																	
ON-055	Maple, Hilltop, and Jackfish Lakes	Fish spawning habitat											X			X		
ON-056	Marlette's Bay	Waterfowl staging area, brood habitat				X									X			
ON-057	Matawin River Nature Reserve	System of productive welands; fish spawning habitat waterfowl staging area, rare plant habitat				X	X								X	X		
ON-058	McInnes Lake and Creek	Fish spawning area														X		
ON-059	Mckellar Peninsula	Shoreline habitat, suitable for peregrine falcon nesting								X			X				X	
ON-060	Megason Lake	Old growth pockets, roadless area; provincially significant wetlands; fish spawning area, headwaters for several rivers	X		X			X	X	X		X				X		
ON-062	Michipicoten Harbor	Fish spawning area														X		
ON-065	Michipicoten River	Fish spawning area/habitat; coastal wetland/estuary					X						X			X		
ON-066	Lower Michipicoten River	Fish spawning habitat											X			X		
ON-067	Mink Creek	Former fish spawning area														X		
ON-068	Montreal Island	Former populations of woodland caribou											X					
ON-069	Montreal River Nature Reserve	Excellent moose habitat										X						
ON-070	Chippewa River Mouth	Fish spawning habitat														X		
ON-074	Gravel River Mouth	Coastal wetland; migratory bird habitat				X									X			
ON-075	Montreal River Mouth	Fish spawning habitat					X						X	X		X		
ON-077	Kabitotikuia River Mouth	Coastal wetland, rare animal habitat; Provincial Nature Reserve	X			X		X				X						
ON-078	Nipigon River and Bay	Significant coastal wetland; waterfowl nesting/staging area; high biodiversity value				X	X	X							X			

ADDENDUM 6-D IMPORTANT HABITAT AREAS OF THE LAKE SUPERIOR BASIN

ON-079	Steel River Mouth	Fish spawning area (river spawning lake trout)											X	X		X		
ON-080	Wolf River Mouth	Coastal wetland with sand dunes; waterfowl nesting/staging area; fish spawning area; rare plant habitat				X	X		X						X	X		
ON-083	Nonwatin Lake and Black Sturgeon River	Fish spawning area										X				X		
ON-084	North Skipper Lake																	
ON-085	Northeast Wilson Island	Rare plant habitat								X			X				X	
ON-086	Northwood Bog	Rare plant habitat											X				X	
ON-087	Schreiber Mine	Rare animal habitat (overwintering area for bats)																
ON-088	Onaman River Mouth	Large wetland; high biodiversity value	X				X					X						
ON-091	Outan Island	Rare animal habitat											X	X				
ON-092	Pancake River	Fish spawning area														X		
ON-093	Parmachene Bridge at Polly Lake												X			X		
ON-094	Pic Dunes	Rare plant habitat; some plants already extirpated from area; Provincial Nature Reserve				X			X	X			X				X	
ON-096	Pic River Mouth	Spawning for lake sturgeon in river											X			X		
ON-097	Pipe River Watershed	Excellent moose habitat; fish spawning area														X		
ON-098	Prince and Jarvis	Undisturbed, diverse habitat; raised cobble beaches and Norwester Chain Mountains				X	X											
ON-099	Jarvey Lake	Fish habitat														X		
ON-100	Quebec Harbor	Fish spawning area														X		
ON-101	Renshaw	Wetland; waterfowl nesting and staging area; rare animal habitat				X	X								X			
ON-102	Robertson Cliffs	Rare animal habitat				X	X			X			X	X				
ON-104	Sand Point	Yellow perch habitat; perch numbers declining														X		
ON-105	Sandy Beach	Shorebird habitat, dune habitat							X	X								
ON-106	Shangoina Island	Rare animal habitat (unoccupied by peregrine falcon), colonial water bird habitat											X			X		
ON-107	Shillibeer Lake	Wetland; staging area for waterfowl				X									X			
ON-108	Montreal Shoreline North	Rare arctic plant habitat								X			X			X		
ON-109	Sturdee Cove Shore	Fish spawning area											X			X		

ADDENDUM 6-D IMPORTANT HABITAT AREAS OF THE LAKE SUPERIOR BASIN

ON-110	Simpson Island	Very important staging area for waterfowl, colonial water bird site,				X						X			X	X		
ON-114	Slate River Drainage	Waterfowl staging and brood habitat													X			
ON-115	Ogilvy Point Islands	Colonial water bird habitat														X		
ON-116	South Fowl Lake	Rare plant habitat (provincially and locally rare plants); Rare animal habitat, excellent waterfowl habitat					X		X	X			X		X			
ON-118	South Michipicoten Island	Fish spawning area											X			X		
ON-119	Speckle Islands	Colonial water bird habitat														X		
ON-120	St. Ignace Island	Rare animal habitat (peregrine falcon unoccupied)											X					
ON-121	St. Ignace and Simpson Islands	Rare animal habitat (woodland caribou unoccupied)											X					
ON-122	Starr Island	Colonial water bird habitat														X		
ON-123	Steamboat Bay	Former fish spawning area														X		
ON-124	The Flats	Rare animal habitat											X					
ON-125	Tunnel Bay	Former fish spawning habitat												X		X		
ON-126	Turkey Lakes	Old growth maple and birch; high biodiversity value (wildlife); roadless area; fish spawning area	X		X		X	X				X				X		
ON-128	Upper St. Mary's River	Fish spawning area														X		
ON-129	West Whitefish Lake	Large inland wetland, waterfowl breeding and staging area, rare animal habitat					X						X		X			
ON-130	Whiskey Point	Significant staging area for waterfowl													X			
ON-132	Wily Lake	Fish spawning area														X		
ON-133	Windikokan Lake	Fish spawning area											X			X		
ON-135	Wolf-Achigan Lakes	Old growth forest, high biodiversity value (landscape level), fish habitat, roadless area	X		X		X	X										
ON-136	Gros Cap Corridor	Migratory fish habitat; commercial fishery; colonial water bird habitat; Gros Cap reef													X	X		
ON-137	Peninsula Harbor	Former fish spawning area; colonial nesting bird habitat														X		
ON-138	Black Bay	Extensive coastal wetlands, diversity of aquatic habitats; provincially significant bog community at east end of bay				X	X									X		
ON-139	Cloud Bay	Coastal wetland, waterfowl migration habitat				X									X			

ADDENDUM 6-D IMPORTANT HABITAT AREAS OF THE LAKE SUPERIOR BASIN

ON-140	Albert Lake Mesa Nature Reserve	Rare plant habitat											X					
ON-141	Castle Creek Nature Reserve	Cliff habitat, wetlands, rare plants							X				X					
ON-142	Cavern Lake Nature Reserve	Arctic-alpine plant community, rare plants, bat hibernaculum							X	X			X		X			
ON-143	Craigs Pit Nature Reserve	Environmentally Sensitive Area; hawk watch site; broken end moraine							X						X			
ON-144	Devon Road Mesa Nature Reserve	Rare plant habitat											X					
ON-145	Divide Ridge Nature Reserve	Cliff habitat										X						
ON-146	Edward Island Nature Reserve	Fish spawning habitat; unique landform vegetation; part of Lake Superior Archipelago														X		
ON-147	Fraleigh Lake Nature Reserve																	
ON-148	Gravel River Nature Reserve	Important staging area for migratory waterfowl; colonial water bird nesting habitat													X	X		
ON-149	Kabitotikwia River Nature Reserve																	
ON-150	Kaiashke Nature Reserve																	
ON-151	Kakabeka Falls	Fish spawning habitat											X			X		
ON-152	Kama Hill Nature Reserve	Kama Cliffs; representative landform and vegetation types (sparse forests and conifer on broken bedrock)							X									
ON-153	Kashabowie	Fish spawning habitat														X		
ON-154	Kopka River	Waterway park																
ON-155	La Verendrye	Rare plant habitat, cliff communities, wild rice marshes					X		X	X		X	X					
ON-156	Lake Nipigon	Woodland caribou calving islands, long undeveloped lakeshore	X				X	X				X	X					
ON-157	Windigo Bay Nature Reserve	Woodland caribou habitat and migration route, sand dune communities	X									X	X	X	X		X	

ADDENDUM 6-D IMPORTANT HABITAT AREAS OF THE LAKE SUPERIOR BASIN

ON-158	Le Pate Nature Reserve	Unique landform feature (mesa)							X									
ON-159	Current River	Fish spawning habitat														X		
ON-160	Little Greenwater Lake Nature Reserve																	
ON-161	Livingstone Point Nature Reserve																	
ON-162	Michipicoten Island	Provincial Park; fish spawning habitat; dune formations; rare plant habitat (Arctic-alpine vascular plants); rare animal habitat							X	X			X					
ON-163	Middle Falls	Fish spawning habitat													X	X		
ON-164	Neys	Remnant woodland caribou population, dune and beach communities; Provincial Park								X			X	X				
ON-165	Obatanga																	
ON-166	Ouimet Canyon Nature Reserve	Arctic-alpine plant community, rare plant habitat							X	X			X					
ON-167	Pantagruel Creek Nature Reserve																	
ON-168	Potholes Nature Reserve																	
ON-170	Prairie River Mouth Nature Reserve	Migratory fish habitat; sandbar, beach ridges, and dunes							X						X			
ON-171	Puff Island Nature Reserve	Environmentally Sensitive Area (unusual geological features, bog area)										X						
ON-172	Pukaskwa National Park	Large intact protected area, woodland caribou population, sand dunes, rare plant habitat	X	X			X	X	X			X	X	X			X	
ON-173	Quetico Wilderness Area	Large Wilderness area																
ON-174	Red Sucker Point Nature Reserve																	
ON-175	Shesheeb Bay Nature Reserve	Fish spawning habitat														X		
ON-176	Silver Falls																	

ADDENDUM 6-D IMPORTANT HABITAT AREAS OF THE LAKE SUPERIOR BASIN

ON-177	Slate Islands	Globally significant woodland caribou population, rare plant habitat							X				X	X			X	
ON-178	Sleeping Giant	Old growth red and white pine stands, rare plant habitat, cliff habitats, coastal wetlands	X		X	X	X	X				X	X					
ON-179	Steel River	Environmentally Sensitive Area; migratory waterfowl site; raptor and wading bird habitat; migratory fish habitat													X	X		
ON-180	The Shoals																	
ON-181	Thompson Island Nature Reserve																	
ON-182	Wabakimi Wilderness Area	Woodland caribou habitat, large pristine protected area	X					X				X	X	X			X	
ON-183	West Bay Nature Reserve	Fish spawning habitat														X		
ON-185	White Lake Peatlands Nature Reserve																	
ON-157	Windigo Bay Nature Reserve	Woodland caribou habitat and migration route, sand dune communities	X									X	X	X	X		X	
WI-001	Montreal River Mouth	Great Lakes costal wetland, old growth white cedar forest			X	X										X		
WI-002	Saxon Harbor	Lake Superior beach, fish spawning area														X		
WI-003	Graveyard Creek	Coastal wetlands, spawning habitat for brook and rainbow trout and coho salmon				X										X		
WI-004	Marble Point	Spawning habitat for lake trout, exposed rocky cliff shore														X		
WI-005	Kakagon Sloughs/Bad River	Largest, healthiest fully-functioning estuarine system in the upper Great Lakes. Rare plant and animal habitat, high biodiversity	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WI-006	Honest John Lake	Coastal wetland includes bog communities, patches of open water, sedge meadow, low shrub and lowland coniferous forest	X	X		X	X	X	X			X	X			X		
WI-007	Oak Point	Coastal wetland. Bog communities are present as linear strips occupying swales between the forested ridges	X			X	X	X				X	X	X	X	X		
WI-008	Long Island	Lake dune landforms, sand beach. Emergent vegetation is common offshore. Rare plant and animal habitat	X			X	X		X	X		X	X	X	X	X		

ADDENDUM 6-D IMPORTANT HABITAT AREAS OF THE LAKE SUPERIOR BASIN

WI-009	Bibon Swamp	Large wetland complex, largest cold water stream system	X				X	X										
WI-010	Apostle Islands	Estensive and diverse natural plant and animal communities. Rare plant and animal habitat	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
WI-012	La Pointe Marina	Coastal wetlands, fish spawning habitat				X										X		
WI-013	Grants Point	Coastal wetland and beach				X												
WI-014	Bog Lake and Amnicon Point	Unprotected sand beach, open-water coastal wetland				X			X	X						X		
WI-015	North Fish Creek Watershed	Old growth forest, fish spawning habitat, rare plant habitat, migratory wildlife areas			X	X	X		X				X					
WI-016	Whittlesey Creek Mouth	Coastal wetlands, fish spawning habitat, groundwater fed river system				X								X		X		
WI-018	Sioux River Wetland Estuary	Extensive coastal and riparian wetlands, sand beach and sandstone cliffs, rare plant habitat, shoreline bog				X			X					X		X		
WI-019	Onion River	Small coastal estuary, fish spawning habitat				X								X		X		
WI-020	Pikes Creek Slough	Coastal estuary wetland community				X								X		X		
WI-021	Schooner Bay/Red Cliff Bay	Small coastal estuary with extensive wetlands.				X												
WI-022	Frog Bay	Small coastal wetland estuary complex				X												
WI-023	Raspberry Bay and River	Great Lakes sand, gravel, and rock shoreline, riparian wetlands, fish spawning habitat				X										X		
WI-024	Little Sand Bay	Coastal wetlands, sand beach, hemlock and cedar forest				X				X								
WI-025	Big Sand Bay /Sand River	Small coastal freshwater estuary, good fish habitat				X										X		
WI-026	Squaw Bay Tributaries	Three small tributaries form small coastal wetlands at their mouths, sand beach, lake trout spawning area off point				X										X		
WI-027	Siskiwit Bay and River	Bay with pawning area for lake whitefish. Shorebirds use the sand beaches of Siskiwit Bay. Riverine fish spawning habitat.				X										X		
WI-028	Lost Creek Natural Area	Extensive coastal wetland,rare plant habitat, shorebird and fish habitats				X							X			X		
WI-029	Bark Bay and Point	Beach dunes landscape, extensive coastal wetlands and bog. The bay supports submergent vegetation.				X			X					X	X	X		
WI-030	Bark River	Extensive riparian wetlands, cedar and white pine forest, fish habitat							X							X		

ADDENDUM 6-D IMPORTANT HABITAT AREAS OF THE LAKE SUPERIOR BASIN

WI-031	Cranberry River State Fishery Area	Great Lakes coastal lagoon and coastal wetlands, diverse fish community				X								X		X		
WI-032	Cranberry River Headwaters	Ground water source for fish habitat						X										
WI-033	Flag River Fishery Area & Port Wing Natural Area	Extensive coastal wetland area, old beach ridges, rare plant habitat				X			X	X				X	X	X		
WI-034a	Mud Lake	Riparian wetland habitat, bog														X		
WI-034b	Millpond Lake	Riparian wetland habitat														X		
WI-034c	Sand Barrens	Rare plant habitat, representative natural community, ecological processes	X					X										
WI-034d	Iron River Mouth	Great lakes coastal wetlands, fish spawning habitat					X		X							X		
WI-034e	Iron River Watershed	Fish spawning habitat	X					X								X		
WI-035	Reefer Creek	Small freshwater estuary, fish spawning habitat				X										X		
WI-036	Fish Creek	Small estuary with coastal wetlands, eroding scarps in unconsolidated sediments				X												
WI-037	Martinson's Landing	Freshwater estuary and coastal wetlands, sand beach, erodible clay banks				X										X		
WI-038	Brule River Watershed	Great Lakes coastal wetlands, fish spawning habitat, old growth forest, riparian wetlands		X		X	X							X		X		
WI-039	Smith Creek Estuary	Coastal wetlands				X												
WI-040	Pearson Creek Estuary	Coastal wetlands, gravel beach, eroding red clay bluffs				X												
WI-041	Poplar River Estuary	Coastal freshwater wetland estuary, fish spawning habitat				X										X		
WI-042	Middle River Estuary	Lake Superior freshwater estuary with coastal wetlands, fish spawning habitat, eroding red clay deposits.				X										X		
WI-043	Amnicon River Estuary	Freshwater estuary with coastal wetlands and sheltered vegetated banks, fish spawning habitat				X										X		
WI-044	Small Estuaries	Several small streams flow through red clay soils and form small estuaries where they enter Lake Superior, alder thickets, shrub carr wetlands				X												
WI-045	Wisconsin Point & Allouez Bay	Bay mouth bar geological feature, longest freshwater sand spit, sand dune ecosystem, colonial waterbird nesting area, migrattory wildlife habitat				X	X		X		X		X	X	X	X		
WI-046	Nemadji River Mouth	Extensive riparian wetlands, great lakes coastal marsh				X										X		

ADDENDUM 6-D IMPORTANT HABITAT AREAS OF THE LAKE SUPERIOR BASIN

WI-047	Hog Island	Shallow open water and wetlands, breeding and migrating waterfowl habitat				X												
WI-048	Superior Municipal Forest	Great Lakes pine forest, rare plant and animal habitat, Great Lakes freshwater estuary			X	X		X										
WI-049	Oliver Wetlands	Great Lakes freshwater estuary, coastal marsh, migratory bird habitat				X		X										
WI-050	Red River	Rare plant habitat, eroding red clay bluffs, fish spawning habitat				X	X	X					X	X		X		
WI-051	Chequamegon Bay	Fish spawning habitat, coastal wetlands	X	X								X				X		
WI-052	Ashland Tern Island	Colonial waterbird nesting habitat, rare animal habitat											X					
WI-053	NSP Tern Island	Colonial waterbird nesting habitat, rare animal habitat											X					
WI-054	Copper Falls State Park	River gorge with falls, old growth mixed northern hardwoods forest	X		X		X	X				X						
WI-055	Big Bay State Park	Coastal lagoon and wetlands complex, floating bog, sand beaches, and unique plant communities.				X			X	X	X		X		X	X		
WI-056	Rainbow Lake Wilderness Area	Representative plant communities, northern hardwood and mixed conifer/deciduous forest communities, old growth forest, diverse habitat types, rare plant and animal habitat.	X	X	X		X	X				X	X					

Definitions

Code	Name	Description
Criteria Code	Criteria Name	Criteria Definition
C1	Rare Communities	Rare communities. Communities that are of high quality, or have high restoration potential, or are critically endangered. Examples include: calcareous fens, beach dunes, interdunal wetlands, red clay wetland complexes, bedrock beaches and cliffs.
C2	Rare Habitats	Plant and wildlife habitats that are rare in the Lake Superior basin, or are rare globally.
C3	Habitat Unique to Great Lakes	Plant and wildlife habitats that occur only in the Great Lakes basin.
C4	Representative Natural Communities	Communities that are, or that with restoration could be, outstanding representatives of the natural (i.e., pre-settlement) ecosystem.
E1	Large Natural Ecosystem	Large, relatively unfragmented areas most representative of the Lake Superior basin ecosystem that support natural community assemblages where ecosystem dynamics are intact or can be restored.

E2	Nationally Significant Ecosystem	Nationally significant ecosystems. Areas that have wildlife and plant habitat values that go beyond local values in that they provide substantial benefits that extend beyond the basin.
E3	Old Growth Forest	Old Growth Forest. Tracts of varying size supporting native old growth forest. Tracts that with restoration and proper management could support high quality, native old growth forest.
E4	Coastal Wetland or Shore	Coastal shore or coastal wetland ecosystems. Sites that have, or with restoration could develop, high quality, diverse ecosystems that are representative of the interacting communities unique to the Lake Superior shoreline.
E5	Diverse Ecosystem	Areas that support high biological and ecological diversity. Sites that support, or with restoration could support the compositional, functional, and structural elements associated with diverse ecosystems.
E6	Ecosystem Integrity Contribution	Habitats that contribute to, or with restoration could contribute to maintaining ecosystem integrity on a landscape scale. These areas could include buffering communities around currently protected ecosystems, core areas within a managed area, or connecting corridors between important habitat sites.
S1	RTE Species Habitat	Sites (large or small) that serve as habitat for vulnerable, endangered, threatened, or special concern species (or candidate species) during any stage of their life cycle. Currently occupied habitats and sites with potential for future colonization or reintroduction are included. Prioritization of potentially occupiable sites depends on the status of the species (i.e., rarity at global, sub-national and basin scales), the liklihood of occupation and the quality (or restoration potential) of the site.
S2	Documented Species Habitat	Sites that serve, or, with restoration, may serve vital functions in the life cycle of species named in appropriate planning documents (e.g., Lake Superior Ecosystem Objectives, Fish Community Objectives for Lake Superior, Tribal resource plans, etc.)
S3	Migration Habitat	Habitats required for the conservation of migratory wildlife (e.g., neotropical migrant birds, anadromous fish, etc.), including staging areas, migration corridors and routes.
S4	Spawning Nesting or Nursery Habitat	Spawning and nursery grounds for reptiles, amphibians, fish, or aquatic invertebrates. Colonial water bird nesting sites.
S5	At Risk Habitat	Habitats that can contribute to the conservation of species most likely to be at risk from human activity.
S6	Ecological Function Habitats	Habitats that support species that provide important ecological functions (e.g., nutrient cycling or chemical detoxification.)

ADDENDUM 6-E. SELECTED STREAM MONITORING DATA FOR ONTARIO TRIBUTARIES (OME DATA).

Stream	Total Alkalinity*	BOD, 5 Day, Total Demand*	Dissolved Organic Carbon*	Conductivity **	dissolvedO_2	Fecal Coliform	pH	Stream Condition	Turbidity***
Agawa River	12.39	0.79	5.13	46.32	11.04	4.21	7.04	0.73	0.88
Aguasabon River	149.89	6.65	8.67	339.21	6.93	5.53	7.54	0.54	3.54
Black River	82.32	1.13	13.68	193.70	10.54	8.52	7.94	2.19	13.50
Black Sturgeon R.	61.41	7.10	12.94	248.03	11.58	4.82	7.69	0.42	4.30
Cedar Creek	56.96	0.83		154.70	9.84	11.50	7.52	0.37	1.04
Cloud River	49.49	1.35	10.50	111.49	11.63	12.38	7.30	0.51	19.63
Coldwater Creek	123.45	1.16	8.00	235.29	11.71	6.37	7.91	0.54	19.25
Dead Horse Creek	33.43	0.81		88.31	10.87	7.00	7.36	0.39	1.53
Gravel River	50.42	1.39	6.67	108.00	12.06	11.79	7.57	0.51	7.91
Hayward Creek	19.60	1.05		1484.26	9.85	10.00	6.87	0.41	1.00
Jackfish River	65.29	1.57	12.00	138.26	10.90	14.03	7.43	0.51	3.63
Jackpine River	26.24	1.16	11.00	65.55	11.79	6.26	7.19	0.53	0.71
Kaministiquia River	41.12	9.33	33.08	161.69	9.22	6441.39	7.28	0.71	10.54
Little Pic River	84.62	8.54	37.36	169.60	11.31	11.29	8.03	2.27	32.85
Magpie River	47.08	0.87	6.52	141.52	11.71	102.95	7.66	0.66	1.59
McIntyre River	75.62	0.79		194.41	11.03	49.72	7.84	0.51	3.30
McKellar River	43.74	2.90		132.08	8.41	1151.72	7.22	0.51	6.51
McVicar Creek	95.70	1.18	12.00	292.18	11.07	556.42	7.91	0.52	8.01
Michipicoten R.	27.90	0.72	6.03	76.65	11.40	1.94	7.43	0.67	1.00
Mission River	40.21	7.28		151.29	8.39	2342.25	7.15	0.52	8.64
Montreal River	21.00	0.68	8.50	64.02	11.19	0.20	7.16	0.64	1.27
Neebing River	106.34	1.93	13.67	291.56	9.43	430.08	7.40	0.52	14.94
Nipigon River	73.34	0.71	7.54	145.74	11.88	7.37	7.90	0.48	4.02
Old Women River	21.06	1.04	5.67	64.19	11.96	2.22	8.78	0.51	1.13
Pays Plat River	14.97	1.52	9.33	46.09	11.79	3.00	6.83	0.52	0.96
Pearl River	55.16	1.51	6.33	123.23	11.55	4.53	7.49	0.51	1.05
Pic River	98.60	1.18	14.44	187.20	10.81	9.66	8.00	2.10	51.19
Pigeon River	31.00	1.53	13.30	91.10	12.14	9.41	7.10	0.51	12.77
Pine River	56.51	1.79	20.33	129.89	11.57	20.71	7.41	0.51	17.89
Prairie River	82.63	1.55	10.00	163.68	11.92	8.69	7.67	0.52	7.65
Sand River	9.19			36.27	10.73		7.09	0.69	1.12

ADDENDUM 6-E. SELECTED STREAM MONITORING DATA FOR ONTARIO TRIBUTARIES (OME DATA).

Stream	Total Alkalinity*	BOD, 5 Day, Total Demand*	Dissolved Organic Carbon*	Conductivity **	dissolvedO_2	Fecal Coliform	pH	Stream Condition	Turbidity***
Silver Creek		1.59		192.58	10.75	0.20		0.51	30.35
Steel River	52.37	0.96	9.00	113.49	12.23	14.79	7.64	0.54	2.62
Wawa Creek	54.66	0.81	5.36	182.48	11.57	5.92	7.69	0.61	3.22
White River	64.52	4.24	9.51	156.99	10.45	6.77	7.65	0.42	1.09
Whitesand River	9.37	0.77		54.98	11.78	10.13	7.04	0.34	0.65
Wolf River	97.26	1.20	10.33	186.47	12.00	2.43	7.86	0.52	5.25
Typical	10 – 100	0.6 – 1.4		73 – 264			7.4 – 8.0		
Polluted (extreme values)	21 – 119	180		1425					

* milligrams per liter, **micromhos/cm at 25^{o}C, ***formazin turbidity unit,

ADDENDUM 6-F . PRESENCE OF FISH SPECIES OBSERVED DURING 1953-1996 IN TRIBUTARIES WITHIN MANAGEMENT UNITS OF LAKE SUPERIOR.

Stream	Stream length (mi)	Miles below barrier	Chinook salmon	Coho salmon	Atlantic salmon	Pink salmon	Rainbow trout	Brown trout	Brook trout	Lake trout	Lake whitefish	Walleye	Lake sturgeon
MN-3													
Cascade		0.1	X				X		X				
Cutface		0.4					X		X				
Fall		0.1					X		X				
Devil Track		1.4					X		X				
Durfee		0.1					X		X				
Cliff		2.0					X		X				
Kimball		1.6					X		X				
Stone		0.1					X		X				
Kadunce		0.4					X		X				
East Colville		0.8					X		X				
Little Brule		0.3					X		X				
Brule		1.5					X		X				
Gauthier		0.2					X		X				
Myhr		0.1					X		X				
Flute Reed		6.7					X		X				
Carlson		0.6					X		X				
Farquhar		1.8					X		X				
Reservation		3.6					X		X				
Hollow Rock		0.1					X		X				
Grand Portage		0.1					X		X				
Pigeon												X	X
subtotal	0.0	22.0	1	0	0	0	20	0	20	0	0	1	1
MN-2													
Gooseberry		0.8					X		X				
Split Rock		0.7					X		X				
Stream #30		0.1					X						
Beaver		0.2					X						
Palisade		1.2					X		X				
Baptism		0.9	X	X			X		X				

ADDENDUM 6-F . PRESENCE OF FISH SPECIES OBSERVED DURING 1953-1996 IN TRIBUTARIES WITHIN MANAGEMENT UNITS OF LAKE SUPERIOR.

Stream	Stream length (mi)	Miles below barrier	Chinook salmon	Coho salmon	Atlantic salmon	Pink salmon	Rainbow trout	Brown trout	Brook trout	Lake trout	Lake whitefish	Walleye	Lake sturgeon
Little Marais		0.1					X		X				
Dragon		0.3					X		X				
Manitou		0.1					X		X				
Little Manitou		0.5					X		X				
Caribou		0.1					X		X				
Sugar Loaf		0.1					X		X				
Last		0.1					X		X				
Section 15		0.1					X		X				
Two Island		0.1					X		X				
Cross		0.3					X		X				
Temperance		0.1					X	X	X				
Onion		0.2					X		X				
Rollins		0.1					X		X				
Poplar		0.1					X		X				
Lutsen		0.1					X		X				
Jonvick		0.1					X		X				
Spruce		0.1					X		X				
Indian Camp		0.8					X		X				
subtotal	0.0	7.3	1	1	0	0	24	1	22	0	0	0	0
MN-1													
St. Louis												X	X
State Line		2.0					X						
Nett		2.0					X						
Little Nett		1.2					X						
Anderson		3.0					X						
Silver		6.5					X						
Nemadji		23.8					X						
Deer		1.0					X						
Blackhoff		12.0					X						
Chester		0.1	X				X						

ADDENDUM 6-F . PRESENCE OF FISH SPECIES OBSERVED DURING 1953-1996 IN TRIBUTARIES WITHIN MANAGEMENT UNITS OF LAKE SUPERIOR.

Stream	Stream length (mi)	Miles below barrier	Chinook salmon	Coho salmon	Atlantic salmon	Pink salmon	Rainbow trout	Brown trout	Brook trout	Lake trout	Lake whitefish	Walleye	Lake sturgeon
Tischer		0.1					X						
Lester		1.1	X				X		X				
Amity		1.3					X		X				
Talmadge		2.0					X		X				
French		0.2	X				X		X				
Schmidt		0.1					X						
Sucker		4.0	X				X		X				
Knife		70.0		X			X	X	X				
Stewart		1.5					X		X				
Little Stewart		2.3					X		X				
Silver		0.5					X		X				
Encampment		0.5					X		X				
subtotal	0.0	135.2	4	1	0	0	21	1	10	0	0	1	1
WI-1													
Nemadji	46.0		X				X	X				X	
Amnicon												X	
Middle							X	X				X	
Poplar												X	
Bois Brule	73.6		X	X			X	X	X			X	
Iron	2.0						X	X					
Flag	16.4		X	X			X	X					
Cranberry	17.1		X	X			X	X					
subtotal	155.1	0.0	4	3	0	0	6	6	1	0	0	5	0
WI-2													
Bark	5.6			X			X	X					
Siskiwit	0.5		X	X			X	X					
Raspberry												X	
Red Cliff Cr.									X				
Pikes	9.0		X	X			X	X					
Onion	4.0			X			X	X	X				

ADDENDUM 6-F . PRESENCE OF FISH SPECIES OBSERVED DURING 1953-1996 IN TRIBUTARIES WITHIN MANAGEMENT UNITS OF LAKE SUPERIOR.

Stream	Stream length (mi)	Miles below barrier	Chinook salmon	Coho salmon	Atlantic salmon	Pink salmon	Rainbow trout	Brown trout	Brook trout	Lake trout	Lake whitefish	Walleye	Lake sturgeon
Sioux	22.0	2.0	X	X			X	X					
Whittlesey	6.8		X	X			X	X					
Fish Cr.	25.4		X	X			X	X					
Kakagon												X	
Bad	85.0		X	X			X	X				X	X
Graveyard	5.5			X			X		X				
Oronto	5.6			X			X						
subtotal	169.4	2.0	6	10	0	0	10	8	3	0	0	3	1
MI-1													
Caribou Cr.		0.4											
Grace Cr.		5.1					X		X				
Feldtman Cr.		0.9											
Big Siskiwit		7.7		X			X		X				
Senter Point Cr.		1.8											
Little Siskiwit		8.6					X		X				
Siskiwit Lake Outlet		0.4					X		X				
Lake Ritchie Cr.		1.4											
Lake Mason Cr.		0.4											
Wallace Lake Cr.		0.3											
Benson Cr.		1.6					X		X				
Moose Lake Outlet		0.1							X				
Hidden Lake Outlet		0.1							X				
Tobin Cr.		3.7							X				
Sargent Lake Cr.		1.3							X				
Chickenbone Lake Cr.		0.5							X				
Beaver Lake Cr.		0.3											
0tter Lake Cr.		0.7											
Todd Harbor Cr.		1.2											
Hatchet Lake Outlet		2.0											

ADDENDUM 6-F . PRESENCE OF FISH SPECIES OBSERVED DURING 1953-1996 IN TRIBUTARIES WITHIN MANAGEMENT UNITS OF LAKE SUPERIOR.

Stream	Stream length (mi)	Miles below barrier	Chinook salmon	Coho salmon	Atlantic salmon	Pink salmon	Rainbow trout	Brown trout	Brook trout	Lake trout	Lake whitefish	Walleye	Lake sturgeon
Pickett Bay Cr.		1.1											
L. Todd Harbor Cr.		0.5											
Washington Cr.		7.5					X		X				
Hugginnin Cr.		0.1					X						
subtotal	0.0	47.7	0	1	0	0	7	0	11	0	0	0	0
MI-2													
Montreal		0.5		X			X					X	
Treasure Cr.		3.0											
Flink Cr.		2.0											
Maki Cr.		2.0											
Ohman Cr.		3.0						X					
Ikwesens Cr.		2.0											
L. Speckled Cr.		2.0					X		X				
Scalp Cr.		2.0											
Killdeer Cr.													
Montana Cr.		1.0											
Ghost Cr.		1.0											
Nighthawk Cr.		2.0											
Maple Cr.		1.0					X		X				
Paleface Cr.		1.0											
Black		0.8	X	X				X					
Chickadee Cr.		2.0											
Bobolink Cr.		2.0											
Tanager Cr.		2.0											
Gijik Cr.		3.0											
Namebinag Cr.		3.0											
Camp B Cr.		3.0											
Presque Isle		0.5					X	X					
Cardinal Cr.		1.0											
Speaker Cr.		4.0					X		X				

ADDENDUM 6-F . PRESENCE OF FISH SPECIES OBSERVED DURING 1953-1996 IN TRIBUTARIES WITHIN MANAGEMENT UNITS OF LAKE SUPERIOR.

Stream	Stream length (mi)	Miles below barrier	Chinook salmon	Coho salmon	Atlantic salmon	Pink salmon	Rainbow trout	Brown trout	Brook trout	Lake trout	Lake whitefish	Walleye	Lake sturgeon
Tiebel Cr.		5.0					X		X				
Kenebeck Cr.		2.0							X				
Pinkerton Cr.		6.0					X						
Little Carp		0.5					X						
Toledo Cr.		3.0											
Carp		1.5					X		X				
Union		4.0					X		X				
Mud Cr.		3.0											
Ash Cr.		5.0											
Little Iron		7.6					X						
Iron		1.0		X			X						
Mineral		15.0	X	X	X		X					X	
Patent Cr.		2.0											
Stony Cr.		7.0											
Pine		9.0											
Duck		10.0											
Halfway Cr.		10.0											
Townline Cr.		10.0											
Little Cranberry		10.0											
Cranberry		13.3					X						
Floodwood		10.0											
Potato		17.6	X	X	X		X	X				X	
Second Cr.		7.0											
First Cr.		7.0											
SEC 11NE Cr.		3.0											
Ontonagon		252.8	X	X			X	X	X			X	
Paddys Cr.		7.0											
Bear Cr.		10.0											
Flintsteel		15.0					X	X					
Firesteel		56.1					X	X	X				

ADDENDUM 6-F . PRESENCE OF FISH SPECIES OBSERVED DURING 1953-1996 IN TRIBUTARIES WITHIN MANAGEMENT UNITS OF LAKE SUPERIOR.

Stream	Stream length (mi)	Miles below barrier	Chinook salmon	Coho salmon	Atlantic salmon	Pink salmon	Rainbow trout	Brown trout	Brook trout	Lake trout	Lake whitefish	Walleye	Lake sturgeon
Tenmile Cr.		5.0											
subtotal	0.0	559.2	4	6	2	0	18	7	9	0	0	4	0
MI-3													
West Sleeping		7.0					X						
East Sleeping		22.0					X						
McCarthy Cr		3.0											
Black Cr.		7.0											
SEC 8 Tributary		5.0											
Misery		1.8		X			X	X	X			X	
Little Elm		6.0		X			X		X				
Elm		15.0		X			X		X				
Graveret		7.0		X			X		X				
Big Cr.													
Deer Lake Outlet													
Hungarian Cr.													
Quincy Cr.													
Dubuque Cr.													
Mud Lake Cr.													
Lily Lake Cr.													
Lovell Cr.													
Mud Lake Outlet		5.6					X		X				
Salmon Trout		0.4		X			X		X				
Schlotz Cr.		5.0					X		X				
Coles Cr.		3.0		X			X		X				
Creek No 1													
Swedetown Cr.		3.0		X			X						
Creek No 3													
Creek No 2													
Creek No 1													
Boston-Lily Cr.		5.0					X	X	X				

ADDENDUM 6-F . PRESENCE OF FISH SPECIES OBSERVED DURING 1953-1996 IN TRIBUTARIES WITHIN MANAGEMENT UNITS OF LAKE SUPERIOR.

Stream	Stream length (mi)	Miles below barrier	Chinook salmon	Coho salmon	Atlantic salmon	Pink salmon	Rainbow trout	Brown trout	Brook trout	Lake trout	Lake whitefish	Walleye	Lake sturgeon
Sand Hill Cr.													
Creek No 5													
Smith Cr.							X		X				
McGunn's Cr.		3.0					X	X	X				
Creek No 2													
Creek No 1													
Gardners Cr.		2.0											
Brewery Cr.		2.0											
Black Cr.													
Hill Cr.		7.0											
Gratiot		1.8					X	X					
Morrison Cr.													
Eagle		1.0											
Garden City Br.		3.0					X						
Jacobs Cr.		0.5											
Owls Cr.		2.0											
Eliza Cr.		3.5					X	X					
Cedar Cr.		2.0											
Silver		0.5											
Glazon Cr.							X						
Fanny Hoe Cr.		0.5	X	X			X						
subtotal	0.0	124.6	1	8	0	0	19	5	11	0	0	1	0
MI-4													
Union Cr.		4.0											
Keystone Cr.		2.0											
Hoar Cr.		1.5											
Montreal		0.5					X						
Bear Cr.							X						
L. Gratiot		7.9					X					X	
Little Betsy		2.0											

ADDENDUM 6-F . PRESENCE OF FISH SPECIES OBSERVED DURING 1953-1996 IN TRIBUTARIES WITHIN MANAGEMENT UNITS OF LAKE SUPERIOR.

Stream	Stream length (mi)	Miles below barrier	Chinook salmon	Coho salmon	Atlantic salmon	Pink salmon	Rainbow trout	Brown trout	Brook trout	Lake trout	Lake whitefish	Walleye	Lake sturgeon
Big Betsy		4.0											
Winters Cr.		0.5											
Tobacco		15.0		X			X						
Chub Eators Cr.													
Traverse		14.7		X			X		X			X	
Lahti Cr.		3.0											
McCallum Cr.		4.0											
Sawmill Cr.													
Trap Rock		15.0		X			X		X			X	
Gooseneck Cr.													
Pilgrim		10.0		X			X		X				
Denton Cr.													
Jarvi Cr.		1.0					X						
Hazel Cr.													
Pike		10.0					X	X					
Sturgeon		104.0		X			X	X				X	X
Snake		3.0											
Kelsey Cr.		6.0					X		X				
Little Carp		7.0		X			X		X				
Hazel Cr.		2.0				X	X						
Black Cr.		2.0				X	X						
Menge Cr.		4.0				X	X	X	X				
Falls		1.2		X		X	X	X	X				
Linden Cr.		5.0						X					
Little Silver Cr.		5.0		X			X		X				
Snug Harbor Cr.		1.0											
Silver		5.5	X	X			X		X			X	
Slate		0.6		X			X		X			X	
Ravine		10.2		X			X		X			X	
Peterson Cr.		4.0											

ADDENDUM 6-F . PRESENCE OF FISH SPECIES OBSERVED DURING 1953-1996 IN TRIBUTARIES WITHIN MANAGEMENT UNITS OF LAKE SUPERIOR.

Stream	Stream length (mi)	Miles below barrier	Chinook salmon	Coho salmon	Atlantic salmon	Pink salmon	Rainbow trout	Brown trout	Brook trout	Lake trout	Lake whitefish	Walleye	Lake sturgeon
Gulskog Cr.		1.0					X						
Huron		16.3		X			X		X			X	
L. Huron		5.0					X		X				
Pine		6.1					X		X			X	
subtotal	0.0	284.0	1	12	0	4	24	5	14	0	0	9	1
MI-5													
Salmon Trout		11.3	X	X		X	X		X			X	
Iron		3.0	X	X		X	X		X			X	
Big Garlic		11.5				X	X		X			X	
Little Garlic		5.9		X		X	X		X				
Harlow Cr.		8.7	X	X			X		X			X	
Campau Cr.		2.0		X			X		X				
Dead		1.1	X			X	X		X			X	
Whetstone Cr		0.5					X	X	X				
Orianna Cr		0.5					X	X	X				
Carp		5.3	X	X		X	X	X	X				
Chocolay		74.8	X				X	X	X			X	
Laughing Whitefish	15.0	10.0	X	X		X	X	X	X			X	
Sand	10.0		X	X			X						
subtotal	25.0	134.6	8	8	0	7	13	5	12	0	0	7	0
MI-6													
Hurricane	7.0			X			X		X				
Sullivan Cr.	2.0			X		X	X		X				
Seven Mile Cr.	5.0						X						
Beaver Cr.	0.5						X						
Spray Cr.	3.0	0.0											
Chapel Cr.	3.5												
Mosquito	5.0	1.0		X			X						
Miners Cr.	10.0	1.0					X		X				
Munising Falls Cr.	1.5	<0.5					X						

ADDENDUM 6-F . PRESENCE OF FISH SPECIES OBSERVED DURING 1953-1996 IN TRIBUTARIES WITHIN MANAGEMENT UNITS OF LAKE SUPERIOR.

Stream	Stream length (mi)	Miles below barrier	Chinook salmon	Coho salmon	Atlantic salmon	Pink salmon	Rainbow trout	Brown trout	Brook trout	Lake trout	Lake whitefish	Walleye	Lake sturgeon
Tannery Falls Cr.	0.8	<0.25					X						
Anna	10.0	<0.5	X	X		X	X	X	X		X		
Unknown 27	0.5												
Bay Furnace Cr.	5.0		X	X		X	X	X	X			X	
Au Train	15.0	10.0	X	X		X	X	X	X			X	
Coots Cr.	0.8												
Rock	10.0	0.1	X	X		X	X	X	X			X	
Deer Lake Cr.	0.5						X						
N. Light Cr.	2.5												
Unknown 18	0.5												
Unknown 19	0.5												
Unknown 20	0.3												
Unknown 21	0.3												
Unknown 22	0.8												
Echo Lake Cr.	0.5												
Unknown 23	0.5												
Unknown 24	0.5												
Unknown 25	0.5												
Unknown 26	0.3												
Gull Pt. Cr.	1.3												
subtotal	88.3	12.1	4	7	0	5	13	4	7	0	1	3	0
MI-7													
Three Mile Cr.	3.0					X	X		X				
L. Two Hearted	10.0			X		X	X		X				
Two Hearted	20.0		X	X		X	X	X	X			X	
Blind Sucker	7.0		X	X		X	X		X				
Sucker	10.0		X	X		X	X		X			X	
Unknown 16	1.2												
Unknown 17	0.5												
Sable Cr.	7.0	<0.5		X		X	X						

ADDENDUM 6-F . PRESENCE OF FISH SPECIES OBSERVED DURING 1953-1996 IN TRIBUTARIES WITHIN MANAGEMENT UNITS OF LAKE SUPERIOR.

Stream	Stream length (mi)	Miles below barrier	Chinook salmon	Coho salmon	Atlantic salmon	Pink salmon	Rainbow trout	Brown trout	Brook trout	Lake trout	Lake whitefish	Walleye	Lake sturgeon
subtotal	58.7	<0.5	3	5	0	6	6	1	5	0	0	2	0
MI-8													
Ashmun Cr.	3.0												
Seymour Cr.	1.0												
Waishkey	15.0		X	X		X	X					X	
L. Waishkey	5.0												
Parish Cr.	2.0												
Club Cr.	1.5								X				
Deep Cr.	0.5												
Zabelka's Cr.	0.3												
Bayou Outlet	0.8												
Pendills Cr.	3.0	<.5	X	X			X		X				
Grant Cr.	2.0		X	X		X	X						
Halfaday Cr.	3.0			X		X	X		X				
Mill Cr.	1.7						X						
Naomikong Cr.	3.0			X			X		X				
Ankodosh Cr.	5.0			X			X						
Rocksbury Cr.	5.0		X	X		X	X		X				
Silver Cr.	2.0												
Galloway Cr.	3.0						X		X				
Tahquamenon	100.0	15.0	X	X		X	X	X				X	X
Black Cr.	3.0						X		X				
Unknown 1	0.5												
O'Brien's Cr.	1.0												
Unknown 2	0.4												
Unknown 3	0.2												
Unknown 4	0.3												
Unknown 5	0.7												
Unknown 6	0.4												
Betsy Cr.	15.0	3.0	X	X			X	X	X			X	

ADDENDUM 6-F . PRESENCE OF FISH SPECIES OBSERVED DURING 1953-1996 IN TRIBUTARIES WITHIN MANAGEMENT UNITS OF LAKE SUPERIOR.

Stream	Stream length (mi)	Miles below barrier	Chinook salmon	Coho salmon	Atlantic salmon	Pink salmon	Rainbow trout	Brown trout	Brook trout	Lake trout	Lake whitefish	Walleye	Lake sturgeon
Unknown 7	1.0												
Unknown 8	1.2												
Unknown 9	0.8												
Unknown 10	0.6												
Unknown 11	0.3												
Unknown 12	0.4												
Unknown 13	0.5												
Unknown 14	0.5												
Unknown 15	0.4												
subtotal	183.8	18.0	6	9	0	5	12	2	8	0	0	3	1
ON-1													
Current									X			X	
McVicar Cr.		3.7					X		X			X	
Mackenzie		1.5				X	X		X				
Portage		0.6					X						
subtotal	0.0	5.8	0	0	0	1	3	0	3	0	0	2	0
ON-2													
Kaministiquia			X									X	X
Whitefish			X										
Neebing		0.1	X				X		X			X	
McIntyre		3.7	X			X	X		X			X	
Subtotal	0.0	3.8	4	0	0	1	2	0	2	0	0	3	1
ON-4													
McKellar												X	
Mission												X	
Whiskeyjack Cr.												X	
Subtotal	0.0	0.0	0	0	0	0	0	0	0	0	0	3	0
ON-5													
Pigeon			X									X	
Jarvis												X	

ADDENDUM 6-F . PRESENCE OF FISH SPECIES OBSERVED DURING 1953-1996 IN TRIBUTARIES WITHIN MANAGEMENT UNITS OF LAKE SUPERIOR.

Stream	Stream length (mi)	Miles below barrier	Chinook salmon	Coho salmon	Atlantic salmon	Pink salmon	Rainbow trout	Brown trout	Brook trout	Lake trout	Lake whitefish	Walleye	Lake sturgeon
Little Pine												X	
Pine												X	
Sturgeon												X	
subtotal	0.0	0.0	1	0	0	0	0	0	0	0	0	5	0
ON-6													
Sibley Cr.		0.9					X					X	
Coldwater Cr.		21.1	X	X		X	X		X				
subtotal	0.0	22.0	1	1	0	1	2	0	1	0	0	1	0
ON-7													
Wolf		6.8	X	X		X	X		X				
Black Sturgeon		9.9	X	X		X	X		X			X	X
Welch Cr.												X	
subtotal	0.0	16.7	2	2	0	2	2	0	2	0	0	2	1
ON-10													
Nipigon			X						X				X
Jackpine									X				
subtotal	0.0	0.0	1	0	0	0	0	0	2	0	0	0	1
ON-11													
Cypress									X				
Little Gravel									X				
Gravel												X	X
Pays Platt												X	
subtotal	0.0	0.0	0	0	0	0	0	0	2	0	0	2	1
ON-12													
S-610												X	
S-608												X	
subtotal	0.0	0.0	0	0	0	0	0	0	0	0	0	2	0
ON-18													
Steel		6.2	X	X	X	X	X		X				
Aguasaubon		0.1					X						

ADDENDUM 6-F . PRESENCE OF FISH SPECIES OBSERVED DURING 1953-1996 IN TRIBUTARIES WITHIN MANAGEMENT UNITS OF LAKE SUPERIOR.

Stream	Stream length (mi)	Miles below barrier	Chinook salmon	Coho salmon	Atlantic salmon	Pink salmon	Rainbow trout	Brown trout	Brook trout	Lake trout	Lake whitefish	Walleye	Lake sturgeon
Fishnet Cr.												X	
subtotal	0.0	6.3	1	1	1	1	2	0	1	0	0	1	0
ON-19													
Dead Horse Cr.												X	
ON-23													
Little Pic			X										
Pic			X									X	X
White			X										
North Swallow		0.1		X			X		X				
Swallow		0.7					X						
White Gravel		1.1					X		X			X	
White			X									X	
Hattie												X	
subtotal	0.0	1.9	4	1	0	0	3	0	2	0	0	4	1
ON-24													
Pukaskwa							X		X				
ON-28													
Dog (University)							X			X		X	
Michipicoten			X									X	X
subtotal	0.0	0.0	1	0	0	0	1	0	0	1	0	2	1
ON-31													
Unamed Cr.									X				
Sand									X				
Agawa												X	
subtotal	0.0	0.0	0	0	0	0	0	0	2	0	0	1	0
ON-33													
Montreal									X	X		X	
Pancake		4.3		X			X		X				
Carp												X	
Batchawana		6.2					X					X	

ADDENDUM 6-F . PRESENCE OF FISH SPECIES OBSERVED DURING 1953-1996 IN TRIBUTARIES WITHIN MANAGEMENT UNITS OF LAKE SUPERIOR.

Stream	Stream length (mi)	Miles below barrier	Chinook salmon	Coho salmon	Atlantic salmon	Pink salmon	Rainbow trout	Brown trout	Brook trout	Lake trout	Lake whitefish	Walleye	Lake sturgeon
Chippewa		0.6	X	X		X	X		X			X	
Harmony												X	
Stokely Cr.		6.5					X					X	
subtotal	0.0	17.6	1	2	0	1	4	0	3	1	0	6	0
ON-34													
Goulais		37.2	X	X		X	X					X	X
Big Carp												X	
East Davingnon Cr.												X	
subtotal	0.0	37.2	1	1	0	1	1	0	0	0	0	3	1
	680.2	1458.1	60	79	3	35	213	45	153	2	1	76	12

APPENDIX 6-G
SPECIES NAMES

Common and scientific names of species mentioned in the text.

Alpine Bistort	*Polygonum viviparum*
Alpine Chickweed	*Cerastium alpinum*
American Beech	*Fagus grandifolia*
American Bison	*Bos bison*
American Brook Lamprey	*Lampetra appendix*
American Crow	*Corvus brachyrhynchos*
American Dune Grass	*Leymus mollis*
American Marten	*Martes americana*
American White Pelican	*Pelecanus erythrorhynchos*
Arctic Grayling	*Thymallus arcticus*
Bald Eagle	*Haliaeetus leucocephalus*
Balsam Fir	*Abies balsamea*
Balsam Poplar	*Populus balsamifera*
Baltic Rush	*Juncus balticus*
Bank Swallow	*Riparia riparia*
Basswood	*Tilia americana*
Bay-breasted Warbler	*Dendroica castanea*
Beach Dune Tiger Beetle	*Cicindela hirticollis*
Beach Pea	*Lathyrus japonicus*
Beaver	*Castor canadensis*
Black Bear	*Ursus americanus*
Black Spruce	*Picea mariana*
Black Tern	*Chlidonias niger*
Black-and-white Warbler	*Mniotilta varia*
Black-capped Chickadee	*Parus atricapillus*
Blackfin Cisco	*Coregonus nigripinnis*
Blanding's Turtle	*Emydoidea blandingii*
Bloater	*Coregonus hoyi*
Bluejoint Grass	*Calamagrostis canadensis*
Blue-spotted Salamander	*Ambystoma laterale*
Bobcat	*Lynx rufus*
Bobolink	*Dolichonyx oryzivorus*
Brook Trout	*Salvelinus fontinalis*
Brown Trout	*Salmo trutta*
Burbot	*Lota lota*
Canada Warbler	*Wilsonia canadensis*
Caspian Tern	*Sterna caspia*
Central Mudminnow	*Umbra limi*
Cerulean Warbler	*Dendroica cerulea*
Chestnut-sided Warbler	*Dendroica pensylvanica*
Chinook Salmon	*Oncorhynchus tshawytscha*
Coho Salmon	*Oncorhynchus kisutch*
Common Bearberry	*Arctostaphylos uva-ursi*

Common Butterwort	*Pinguicula vulgaris*
Common Ground Juniper	*Juniperus communis*
Common Tern	*Sterna hirundo*
Common Yarrow	*Achillea millefolium*
Connecticut Warbler	*Oporornis agilis*
Coyote	*Canis latrans*
Creeping Juniper	*Juniperus horizontalis*
Dark-eyed Junco	*Junco hyemalis*
Deepwater Cisco	*Coregonus johannae*
Deepwater Sculpin	*Myoxocephalus thompsoni*
Devil's-club	*Oplopanax horridus*
Double-crested Cormorant	*Phalacrocorax auritus*
Dune Cutworm	*Euxoa aurulenta*
Eastern American Toad	*Bufo americanus americanus*
Eastern Cougar	*Felis concolor couguar*
Eastern Newt	*Notophthalmus viridescens viridesce*
Eastern Pipistrelle	*Pipistrellus subflavus*
Eastern Redback Salamander	*Plethodon cinereus*
Eastern Small-footed Bat	*Myotis leibii*
Eastern White Cedar	*Thuja occidentalis*
Eurasian Water Milfoil	*Myriophyllum spicatum*
European Hare	*Lepus europaeus*
European Starling	*Sturnus vulgaris*
False Northwestern Moonwort	*Botrychium pseudopinnatum*
Giant Reed	*Phragmites australis*
Ginseng	*Panax quinquefolius*
Glossy Buckthorn	*Rhamnus frangula*
Golden-crowned Kinglet	*Regulus satrapa*
Gray Partridge	*Perdix perdix*
Great Blue Heron	*Ardea herodias*
Great Gray Owl	*Strix nebulosa*
Green Ash	*Fraxinus pennsylvanica*
Gypsy Moth	*Lymantria dispar*
Hemlock	*Tsuga canadensis*
Hermit Thrush	*Catharus guttatus*
Herring Gull	*Larus argentatus*
Houghton's Goldenrod	*Solidago houghtonii*
House Mouse	*Mus musculus*
House Sparrow	*Passer domesticus*
Ives Lake Cisco	*Coregonus hubbsi*
Jack Pine	*Pinus banksiana*
Kiyi	*Coregonus kiyi*
Lake Chub	*Couesius plumbeus*
Lake Herring or Cisco	*Coregonus artedi*
Lake Huron Locust	*Trimerotropis huroniana*
Lake Huron Tansy	*Tanacetum huronense*
Lake Sturgeon	*Acipenser fulvescens*
Lake Whitefish	*Coregonus clupeaformis*

Leopard Frog	*Rana pipiens*
Little Bluestem	*Schizachyrium scoparium*
Lynx	*Lynx canadensis*
Marsh Spikerush	*Eleocharis smallii*
Merlin	*Falco columbarius*
Moose	*Alces alces*
Mountain Avens	*Dryas drummondii*
Nashville Warbler	*Vermivora ruficapilla*
Ninespine Stickleback	*Pungitius pungitius*
Nipigon Tullibee	*Coregonus nipigon*
Northern Brook Lamprey	*Ichthyomyzon fossor*
Northern Eyebright	*Euphrasia hudsoniana*
Northern Myotis	*Myotis septentrionalis*
Northern Pike	*Esox lucius*
Northern Saw-whet Owl	*Aegolius acadicus*
Northern Shrike	*Lanius excubitor*
Northern Spring Peeper	*Pseudacris crucifer crucifer*
Northern Waterthrush	*Seiurus noveboracensis*
Norway Rat	*Rattus norvegicus*
Norwegian Whitlowgrass	*Draba norvegica*
Osprey	*Pandion haliaetus*
Ovenbird	*Seiurus aurocapillus*
Paddlefish	*Polyodon spathula*
Pale Moonwort	*Botrychium pallidum*
Palm Warbler	*Dendroica palmarum*
Peregrine Falcon	*Falco peregrinus*
Pink Salmon	*Oncorhynchus gorbuscha*
Piping Plover	*Charadrius melodus*
Pitcher's Thistle	*Cirsium pitcheri*
Pointed Moonwort	*Botrychium acuminatum*
Porcupine	*Erethizon dorsatum*
Purple Loosestrife	*Lythrum salicaria*
Pygmy Whitefish	*Prosopium coulteri*
Queen of the Meadow	*Filipendula ulmaria*
Raccoon	*Procyon lotor*
Rainbow Smelt	*Osmerus mordax*
Rainbow Trout	*Oncorhynchus mykiss*
Red Fox	*Vulpes vulpes*
Red Osier Dogwood	*Cornus stolonifera*
Red Pine	*Pinus resinosa*
Red-headed Woodpecker	*Melanerpes erythrocephalus*
Red-shouldered Hawk	*Buteo lineatus*
Red-tailed Hawk	*Buteo jamaicensis*
Reed Canary Grass	*Phalaris arundinacea*
Ring-billed Gull	*Larus delawarensis*
River Otter	*Lontra candensis*
Rock Cranberry	*Vaccinium vitis-idaea*
Rock Dove	*Columba livia*

Rock Vole	*Microtus chrotorrhinus*
Rocky Mountain Fescue	*Festuca saximontana*
Rose-breasted Grosbeak	*Pheucticus ludovicianus*
Round Goby	*Neogobius melanostomus*
Round Whitefish	*Prosopium cylindraceum*
Ruffe	*Gymnocephalus cernuus*
Rusty Crayfish	*Oronectes rusticus*
Sandcherry	*Prunus pumila*
Scarlet Tanager	*Piranga olivacea*
Sea Lamprey	*Petromyzon marinus*
Sharp-shinned Hawk	*Accipiter striatus*
Shortjaw Cisco	*Coregonus zenithicus*
Shortnose Cisco	*Coregonus reighardi*
Shrubby Cinquefoil	*Potentilla fruticosa*
Siskiwit Lake Cisco	*Coregonus bartlettii*
Slimy Sculpin	*Cottus cognatus*
Smallmouth Bass	*Micropterus dolomieu*
Snowshoe Hare	*Lepus americanus*
Snowy Owl	*Nyctea scandiaca*
Speckled Alder	*Alnus incana*
Splake	*Salvelinus fontinalis X S.namaycush*
Spruce Budworm	*Choristoneura fumiferana*
Sugar Maple	*Acer saccharum*
Swainson's Thrush	*Catharus ustulatus*
Tall Wormwood	*Artemisia campestris*
Tennessee Warbler	*Vermivora peregrina*
Thirteen-lined Ground Squirrel	*Spermophilus tridecemlineatus*
Timber Wolf	*Canis lupus*
Trembling Aspen	*Populus tremuloides*
Trout-perch	*Percopsis omiscomaycus*
Trumpeter Swan	*Cygnus buccinator*
Twig Rush	*Cladium mariscoides*
Valarian	*Valeriana officinalis*
Veery	*Catharus fuscescens*
Walleye	*Stizostedion vitreum*
Wapiti, Elk	*Cervus elaphus*
Whip-poor-will	*Caprimulgus vociferus*
White Bass	*Morone chrysops*
White Birch	*Betula papyrifera*
White Pine	*Pinus strobus*
White Spruce	*Picea glauca*
White-tailed Deer	*Odocoileus virginianus*
Wild Chives	*Allium schoenoprasum*
Wild Rice	*Zizania palustris*
Wolverine	*Gulo gulo*
Wood Frog	*Rana sylvatica*
Wood Thrush	*Catharus mustelinus*
Wood Turtle	*Clemmys insculpta*

Woodland Caribou	*Rangifer tarandus*
Yellow Birch	*Betula alleghaniensis*
Yellow Rail	*Coturnicops noveboracens*
Yellow-bellied Flycatcher	*Empidonax flavivent*
Yellow-billed Cuckoo	*Coccyzus americanus*
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*
Yellow-rumped Warbler	*Dendroica coronata*
Zebra Mussel	*Dreissena polymorpha*

ADDENDUM 6-H. LAKE SUPERIOR HABITAT MAP (PLACEHOLDER)

Chapter 7

Terrestrial Wildlife Communities Progress Report

Insert at beginning of LaMP 2000 Chapter 7.

Bull Moose, Superior National Forest
Photograph by USDA Forest Service

Lake Superior Lakewide Management Plan
2004

Chapter 7 Contents

Chapter 7
The Terrestrial Wildlife Community

7.0 INTRODUCTION

The members of the Terrestrial Wildlife Community Committee (TWCC) come from a wide variety of agencies and educational institutions around the basin. There are members from both the U.S. and the Ontario side of the basin. On the US side, TWCC members come from all three states in the Lake Superior Basin (Minnesota, Michigan, and Wisconsin) as well as several federal and Tribal agencies. Non-profit organizations are represented by the Sigurd Olson Environmental Institute. On the Canadian side, Ontario Ministry of Natural Resources is represented. Universities are represented by Lakehead University, Northland College, and University of Minnesota, Duluth.

Just as there are many participants in the Lake Superior Binational Program, there are many agencies that are contributing to the implementation of the Lake Superior Management Plan and the vision set forth in that plan. The projects and their accomplishments listed below represent a sampling of all of the activities taking place in the basin.

7.1 LaMP ACCOMPLISHMENTS 2002 TO 2004

Ontario's Herpetofaunal and Rare Plant Inventories in the Lake Superior Basin

As identified in the LaMP 2000 document, knowledge of both herpetofaunal (reptile & amphibian) and rare plant populations and distributions within the Lake Superior Basin are incomplete and fragmented. This project is aimed to fill in some of our knowledge gaps in the distribution and relative abundance of reptiles, amphibians and rare plants within the Ontario portion of the basin.

Standard inventory techniques will be utilized for both herpetofaunal (e.g., pond searches, auditory surveys, and litter/debris searches) and rare plant surveys. Specimens will be photographed and accurate locational data recorded so that inventory results can be mapped.

This project provides direct linkages to LaMP 2000 Terrestrial Wildlife Inventory Strategy A – inventory all levels of the biotic community, assess wildlife needs and develop actions for protection, maintenance and restoration, with priority attention to groups for which little is known. This undertaking also supports a number of Ontario's provincial priority program areas including the Species at Risk program (SAR).

Development and Evaluation of Species Monitoring Protocols

This Ontario Ministry of Natural Resources (OMNR) project, started in 2003, will initiate implementation of monitoring protocols, sampling procedures, and data handling for identified high priority "best bet" indicators species. The project is designed to identify one "best bet" indicator each year (2003, 2004, and 2005) and develop a basin-wide monitoring protocol for that indicator. The monitoring protocol will be evaluated under field conditions during subsequent field seasons and its utility evaluated and appropriate modifications made as appropriate. Year one is aimed at developing basin-wide monitoring protocols for reptiles and amphibians.

Monitoring protocols will be developed using a "species expert" workshop approach. The first workshop will initiate the process of identifying appropriate species to monitor within the basin. This will be followed by a further workshop(s) to develop an appropriate monitoring protocol for the preferred indicators, peer review of the proposed monitoring protocol, and subsequent publication of the protocol for distribution to workshop participants and agency personnel within the basin. The second year will see the development of monitoring protocols for the next "best bet" and an evaluation of the proposed monitoring protocols utilized to date.

Wood Turtle Recovery Plan Implementation Project

Wood Turtles (*Glyptemys insculpta*) are a small (average 20 cm), docile turtle displaying colourful markings that makes them popular targets for the pet trade. They have been designated a species of "Special Concern" (Litzgus and Brooks 1996) by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC); in Ontario they are designated "Vulnerable," but have been recommended for "Endangered" status by the Committee on the Status of Species at Risk in Ontario (COSSARO). Despite these listings, and the inclusion of Wood Turtles on CITES (Convention on International Trade in Endangered Species), this species has suffered population declines throughout their range due to habitat destruction and commercial collecting (Harding and Blooer 1979; Garber and Burger 1995). Collectors can easily harvest an entire population in only one or two years by timing their exploitation to coincide with the turtles' emergences from hibernation (Anon. 2000; Cameron and Brooks 2002).

During the spring and summer of 2002, the Ontario government provided "Species at Risk" funds to begin a study of Wood Turtles within the Lake Superior basin. This study resulted in locating Wood Turtle populations in 4 streams of 11 searched. There are another 13 streams that have not been surveyed. Of these 4 streams, one was found to have a healthy population and has therefore been proposed as a candidate for "The Room to Grow" program as a new protected area (Knudsen and Crins, 2002). Due to the undisturbed nature of the habitat in the Lake Superior Basin, this population is one of the last refuges for the Wood Turtles in Ontario.

The focus of the newest project initiated in 2003 and funded under Ontario's commitment to COA (Canada-Ontario Agreement), is to locate new populations and to monitor existing populations for population demographics in adherence with the Ontario Wood Turtle Recovery Plan (revised, 2002). The Ontario Turtle Recovery Team implements this plan on a provincial basis. Therefore, data collected, the habitat suitability model developed and the studies currently on-going on the other populations in the province, will be analyzed and compared to assist in the development of a province-wide protection guidelines. In addition, marking techniques and DNA profiling have been undertaken through a partnership with Trent University to protect these vulnerable populations from poaching activities.

Northwestern Lake Superior Peregrine Falcon and Bald Eagle Monitoring

This project was initiated in 2003 to monitor endangered bird species in Ontario's portion of the Lake Superior basin. The focus was to inventory and monitor nest success of Peregrine Falcons and Bald Eagles within the Thunder Bay and Terrace Bay areas of the Lake Superior Coast.

Boat and helicopter surveys were used to identify birds and map locations of active territories. The origin of adult falcons or eagles was established where possible through identification of colour leg bands. Nesting success was monitored at a number of sites. Through repeat visits at critical stages of development, the banding of Peregrine chicks took place to estimate dispersal and post-fledgling survival in subsequent surveys. Mapping of nesting locations and active territories was also undertaken and will contribute to Ontario's provincial GIS database.

Knowledge of nesting activities will assist in determining species recovery success and will be used in a variety of planning roles (municipal, provincial and Lake Superior LaMP). This project is scheduled to continue through 2005.

Minnesota Department of Natural Resources (MN DNR)

- **North Shore State Parks Spruce Beetle Study.** A $26,000 grant to MN DNR to determine the extent of spruce beetle infestation in state parks and to determine population trends.

- **Shoreline Plant Community Survey.** A $30,000 grant to MN DNR to evaluate the impacts of visitor use on native plant communities on public lands by comparing areas of high use in state parks to areas of moderate and low use on public and private lands.

- **The Minnesota County Biological Survey.** Engaged in an intensive, systematic survey of high quality natural plant communities in the North Shore Highlands subsection for the past several years. Plant community survey work is nearing completion. Animal Survey work is underway and is scheduled to continue for at least another field season. Surveys of hepetofauna and bats are notable components of this survey.

Wisconsin Department of Natural Resources (WDNR)

- **Common Tern Habitat.** In the fall of 2002, a new island was built for common terns, a Wisconsin endangered species, in Ashland. The Ashland colony is one of only two common tern nesting colonies in the entire Lake Superior basin. The other colony is located on Interstate Island in the St. Louis River estuary. There was a slight increase in the number of nesting pairs using the new island in 2003 with about 90 pairs of terns nesting. Production was one of the highest ever observed with nearly two young fledged per nest.

- **Forest Openings.** Maintenance of small grassy openings within blocks of publicly managed forestlands provides habitat for many animals such as flickers, cedar waxwings, chestnut-sided warblers, mourning warblers, broad-winged hawks, smooth green snakes, leopard frogs, badgers, bear, and provide critical feeding area to deer after severe winters. Wisconsin's Lake Superior Basin counties have approximately 2,000 openings on state and county forest lands. Openings are maintained by a variety of methods including mowing, hand cutting, and herbicide treatment of woody vegetation.

- **Sedge Pond Project for Native Species Establishment in Restored Wetlands.** The WDNR has developed a project plan and is seeking funding to develop a local sedge nursery pond. The project would involve construction of a three-acre pond with water control capabilities at the University of Wisconsin Ashland Agricultural Research Station. The pond would serve as a nursery for native sedges and rushes, which would be harvested periodically for use as a seed source for wetland restoration and creation projects in the Lake Superior Basin. This project will attempt to establish a diverse stand of native sedges and rushes from seed, and develop a protocol for successful mechanical harvesting of seed and establishment of these plants in other wetland projects in the basin.

- **Native Grass and Forb Nursery.** WDNR has developed plans and is seeking funding for the construction of a 10+ acre native grass and forb nursery at the University of Wisconsin Ashland Agricultural Research Station. The purpose of the project is to create a readily accessible seed mix source for habitat improvement projects in the Lake Superior Basin.

- **Sharp-tailed Grouse Reintroduction.** A sharp-tailed grouse reintroduction project is being coordinated in a 12,000-acre agricultural area just south of the City of Ashland. At the request of several landowners, the WDNR completed an evaluation of the area to determine habitat suitability. Maintenance of existing grasslands and brushlands along with some conversion of woodland edge and creation of additional brushlands, should provide adequate habitat to sustain a small population. The entire project area is privately owned and divided into many small parcels. Over 170 landowners have been contacted to determine their interest in managing their lands for suitable habitat. If support for this proposal continues, a release of wild captured birds could take place as early as 2005. Long-range goals include creating corridors to existing populations in northern Wisconsin, thereby improving genetic diversity among the population.

- **Wisconsin State Natural Areas.** The WDNR conducted Phragmites (giant reed) control on three acres of a six-acre stand in the Bark Bay Sloughs State Natural Area. Phragmites contol efforts will continue in 2004. Wetland restoration of 2.4 acres on two private properties included agreements to maintain adjacent grasslands in undisturbed condition during the nesting and early brood rearing seasons. WDNR restored a rock entry barrier to the beach to prevent further habitat degradation from inappropriate motor vehicle access at Port Wing Boreal Forest State Natural Area.

U.S. Department of Agriculture
Forest Service

Invasive Species

- The Eastern Region of the Forest Service **Non-Native Invasive (NNIS) Species Framework** was released in April 2003. Its focus includes leadership, prevention, early detection and rapid response, control and management, restoration, cooperation, research and information, and education.

- The Eastern Region is providing leadership for the **Midwest Natural Resource Group** (MNRG) in FY 2003. A memorandum of understanding has been signed, and plans are being made to develop early detection and rapid response plans for aquatic and terrestrial NNIS in the Midwest. The region is also providing leadership to form a Midwest NNIS plants group in conjunction with MNRG.

- National Forests in the basin treated 143 acres for invasive species control in Fiscal Year 2003.

Wildlife

- 647,000 acres of Canada Lynx were inventoried.
- Initiated a 5-year study of Canada Lynx in the Superior National Forest.
- Completed annual wolf monitoring.
- Participated in the annual breeding bird survey.
- Regional Forester’s Sensitive Species (665 species) update completed in 2003.
- Conservation assessments (665 sensitive species needing assessments):
    - 35% Completed
    - 42% Pending
    - 23% In progress

U.S. Department of Interior
National Park Service

Apostle Islands

- Restoration of Oak Island Sandscape began in 2000 with the primary restoration in 2001 and 2002. Monitoring of the sandscape occurred through 2003.

- Restoration of old cabin sites began in 2003 and will continue in 2004. In a cooperative effort with NRCS, native plants were gathered and propagated to be used in the restoration effort.

- In a cooperative effort with FWS and NRCS, restoration of South Twin and Raspberry Sandscapes began in 2003.

- Estimated the relative abundance of American otter.

- Monitored beaver populations.

- Estimated relative abundance of deer on 2 islands of the Apostle Islands National Lakeshore. A browse survey was conducted on Sand Island in 2003.

- Regular monitoring was conducted of breeding birds, migratory birds, water quality, sandscape monitoring, purple loosestrife control, spotted knapweed control, and eagle nests.

Pictured Rocks

The following studies were completed:

- Refinement of small carnivore monitoring techniques.

- Resource selection by sympatric fisher and American marten.

- Effects of human disturbance on black bear distribution.

- Forest carnivore survival and mortality factors.

- Diet of forest carnivores.

- Suitability of otter hair to assess mercury levels.

- Avian response to hiker disturbance.

- Avian community structure in relation to landscape- and stand-level characteristics.
- Landscape-scale vascular plant abundance and distribution.
- Distribution and abundance of down woody materials.
- Management impacts upon forest structure and composition.

Grand Portage

The following studies were completed:

- Night-calling bird survey. 2004 is the final year of four-year effort to document bird species not detected in traditional breeding bird survey.
- Migrant/Winter bird survey. Fall 2003/Spring 2004 effort to document species not detected in traditional breeding bird survey.
- Annual Breeding Bird Survey.
- Vegetation monitoring (five-year cycle of only two stands).
- Historic disturbance regimes and natural variability of Grand Portage National Monument forest ecosystems.
- Forest history study to assist with future management decisions for forested trail corridor of the Monument.
- Inventory of ground beetles and characterization of the vegetation of Grand Portage National Monument.
- Effort to evaluate disturbance history of trail corridor habitats to guide future management.
- Initial inventory of the moths of Grand Portage National Monument, Cook County, Minnesota.
- Inventory of caddis flies of Grand Portage National Monument, Cook County, Minnesota.

US Department of Interior
Fish and Wildlife Service

- **Partners for Fish and Wildlife Program.** Wildlife habitat restoration on private land in Lake Superior basin during the reporting period: 179 acres of wetlands enhanced or restored and 64 acres of upland habitat enhanced or restored.

Superior Coastal Wetlands Initiative - Phase II Moving Forward

This highly successful partnership made up of communities, tribes, non-government organizations and agencies is working together to conserve wetlands in Lake Superior's Chequamegon Bay area. Through the hard work and over $5,500,000 in matching contributions by the partners, North American Wetland Conservation Act (NAWCA) grants totaling nearly $2,000,000 have been secured. Wetlands make up 10 percent of Wisconsin's Lake Superior watershed and play a critical role in the sustainability of the region's wildlife populations.

Nearly 10,000 acres of fish and wildlife habitat was restored, enhanced or protected in Phase I of the project. Highlights included establishment of the Whittlesey Creek National Wildlife Refuge and acquisition of lands within it. The restoration and enhancement of 4,383 acres of wildlife habitat in the watershed, and the acquisition of over 2,000 acres of critical coastal wetland/bottomland forest and associated uplands in the Kakagon/Bad River Sloughs.

Phase II is now underway and the partners of the Superior Coastal Wetland Initiative are targeting priority wetlands and their watersheds.

- The Kakagon/Bad River sloughs and associated Bad River watershed.
- Fish Creek Sloughs and watershed.
- Whittlesey Creek.
- Frog River.
- Raspberry River and estuary.

The objectives of Phase II are to acquire 1,037 acres of wetlands and 1,433 acres of upland in fee title, acquire 250 acres of wetland and 435 acres of uplands through easements, restore 249 acres of wetlands, enhance 70 acres of wetlands, and set aside 2,500 acres through a conservation stewardship program on private lands.

- **Great Lakes Coastal Program.** During the reporting period, partnered on 21 projects in the Lake Superior Basin. The program provided funding for restoration (7), research (12), outreach and education (2) projects. Restoration projects accounted for 814 acres of fish and wildlife habitat enhanced or restored and 2 ½ miles of stream habitat enhanced or restored.

- **North American Woodcock Singing Ground Survey.** As part of the U.S Fish and Wildlife Service and Canadian Wildlife Service's North American Woodcock Singing Ground Survey, the service's Ashland Fishery Resources Office surveyed some of the Wisconsin routes in the Lake Superior basin. This annual survey provides an index to the relative size of the woodcock breeding population and is the most important source of data used to guide the United States and Canadian woodcock programs.

- **Whittlesey Creek NWR.** Acquired 105 additional acres of land within the proposed refuge boundary in three separate parcels. Total acreage owned to date is 220 out of 540 acres to be acquired.

- **Whittlesey Creek NWR Forest Restoration.** Whittlesey Creek National Wildlife Refuge restored and enhanced approximately 22 acres of riparian forest along Terwilliger Creek. Native trees and shrubs were used in the restoration and planted in a manner that will increase the landscapes value to fish and wildlife. The restored area will benefit conservation priority migratory bird species such as the wood thrush, northern flicker and American woodcock. It will also improve water quality and habitat for coaster brook trout as well as other fish that spend all or part of their life cycles in refuge streams.

- **Great Lakes Piping Plover Recovery.** In May 2001, the U.S. Fish & Wildlife Service designated critical habitat for the Great Lakes piping plover, a federally endangered species. Critical habitat receives protection under section 7 of the Endangered Species Act through the prohibition against destruction or adverse modification with regard to actions carried out, funded, or authorized by Federal agencies. Critical habitat was designated throughout all of the Great Lakes basins. Within the Lake Superior basin five critical habitat "units" were designated totaling 73 miles (120 km) of shoreline in Michigan, Wisconsin, and Minnesota. Once found breeding in many places along Lake Superior, piping plovers currently nest in only two shoreline areas. Protection of critical habitat will facilitate recovery and return of piping plovers to many historical breeding sites on Lake Superior and throughout the Great Lakes.

Additional projects included the following:

- Participated in the annual Breeding Bird Survey.

- U.S. Geological Survey completed the ground-water flow and rainfall runoff models for Whittlesey Creek and published their report in 2003.

- Planted 10 acres of trees as a riparian forest restoration project within the Whittlesey Creek National Wildlife Refuge.

- Celebrated National Wildlife Refuge Centennial at special events that highlighted history of Lake Superior, Coaster Brook Trout rehabilitation efforts, and habitat restoration efforts.

- Initiated a purple loosestrife control project on the refuge through biological control.

- Mapped habitat types within the Whittlesey Creek NWR boundary. The information will be used to develop a habitat management plan for the refuge.

Indian Tribes

Keweenaw Bay Indian Community

The following projects were completed:

- Conducted fall waterfowl surveys at 4 area wetlands.

- Completed frog and toad index surveys at 11 sites.

- Maintained 30 artificial duck next boxes at 5 wetlands.

- Expanded Reservation wildlife refuge system to its present level of 926 acres.

- Monitored harvested deer for chronic wasting disease.

- Created a new waterfowl impoundment of 10 acres (Roubillard wetland) on a 30-acre refuge.

Fond du Lac Band

The following projects were completed:

- Conducted population surveys for ruffed grouse, wood turtles, frogs and toads, loons, small mammals, furbearers, wolves and moose.

- Collected samples from harvested deer for CWD monitoring.

- Worked on moose research involving population dynamics and movements.

- Used prescribed fire to improve habitat for waterfowl, sharptail grouse, moose and deer.

- Provided comments on the draft Superior National Forest Management Plan.

Herptile Workshop Held with Society of Conservation Biology Annual Meeting

The Terrestrial Wildlife Community Committee of the Lake Superior Binational Program organized a herptile monitoring workshop in Duluth, MN, held in conjunction with the 2003 *Society for Conservation Biology* annual meeting. The goal of the one-day workshop was to bring together reptile and amphibian experts from around the Lake Superior Basin to initiate discussion for the implementation of a basin-wide herptile monitoring program.

Specific workshop objectives were:

- To identify species that warrant monitoring,
- To identify which species can be effectively monitored, and
- To begin discussing appropriate monitoring methods or techniques for the species identified.

The State of the Lake Ecosystem Conference and the 2000 Lake Superior Lake-wide Management Plan identified reptiles and amphibians as a critical group to be monitored, since they are sensitive to both anthropogenic perturbations and to chemical contaminants. It is believed that since Lake Superior is at the northern edge of the natural range of many herptile species declines in their abundance within the basin may be indicative of pending declines elsewhere. Herptiles may also be particularly useful for monitoring in the Areas of Concern document progress in remediation and restoration at those sites.

Thirty-seven amphibian and reptile species occur in, and are considered ecologically significant components of, the Lake Superior watershed as identified by Gary Casper in "*A Review of the Amphibians and Reptiles of the Lake Superior Watershed, Technical Report provided to the Terrestrial Wildlife Community Committee, for the Lake Superior Lakewide Management Plan*," submitted by G. Casper, 2002.

Nine 20-minute presentations were given during the afternoon session of the workshop. The session opened with a presentation outlining the range and status of each herptile species found in the basin. A moderated, round-table discussion aimed at establishing herptile monitoring priorities in the Lake Superior basin was the focus of the workshop's evening session. Initial discussions concentrated on determining the most acceptable means of identifying those herptile species that warranted monitoring.

Of the 37 species present in the basin, 30 species were identified and placed into one or more of 10 monitoring methods. Monitoring methods selected were:

- calling surveys
- aquatic cover objects
- general cover objects
- aquatic funnel traps
- hoop net traps
- basking traps
- visual encounters
- egg mass surveys
- drift fences with traps
- dip net surveys

Great Lake Indian Fish and Wildlife Commission

The following projects were completed:

- Surveyed over 400 deer for chronic wasting disease.

- Completed years 1 and 2 of a collaborative (US Forest Service) research project designed to examine factors affecting successful dispersal of American marten and the Chequamegon National Forest.

- Conducted sharp-tailed grouse drumming counts on Moquah barrens, Wisconsin

Other Committee Accomplishments

- Nearing completion of integration of the four ecosystem chapters of the LaMP 2000 – Aquatics, Habitat, Terrestrial, Wildlife and Exotic Species.

- Completed setting long- and short-term ecosystem goals for LaMP implementation (jointly with aquatic and habitat committees).

- Approved and accepted final reports on herptile and soil invertebrate indicator projects.

- Held a herptile workshop in Duluth, MN.

- Completed an inventory of recovery plans or conservation strategies for Threatened and Endangered species (and their Canadian equivalents). Completed inventory of extirpated, recovered and reintroduced species.

7.2 CHALLENGES AND NEXT STEPS FOR 2004 TO 2006

Over the next two years, the committee will do the following:

- Continue to develop and implement a biological community-based monitoring program;
- Consolidate the ecosystem chapters of LaMP 2000;
- Continue to develop and implement a herptile monitoring program; follow up on the herptile monitoring workshop.
- Develop a method to monitor land use change over time;
- Initiate development of a monitoring program for medium sized carnivores;
- Combat the spread of exotic and invasive species; and
- Continue to encourage partner agencies to design and implement priority LaMP projects.

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Members of the Terrestrial Wildlife Community Committee

Committee Co-Chairs

Jonathan Gilbert	US Co-Chair, Great Lakes Indian Fish and Wildlife Commission
Neil Dawson	Canadian Co-Chair, Ontario Ministry of Natural Resources

Committee Members

Julie Van Stappen	- Apostle Island National Lakeshore
Paul Sandstrom	- Natural Resources Conservation Service
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Chapter 7

Terrestrial Wildlife Communities

Eaglets
Photograph by: Ron Eckstein, WI DNR

Lake Superior Lakewide Management Plan
2000

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EXECUTIVE SUMMARY

The mission of the Terrestrial Wildlife Community Committee (TWCC) is to support a diverse, healthy, and sustainable native wildlife community in the Lake Superior basin. The work of the TWCC is guided by the following principles:

- Encourage disturbances that are within natural variation.
- Manage land and wildlife populations using practices that mimic natural variation.
- Understand the relationship between wildlife and disturbance.
- Keep wildlife species free of contamination.
- Encourage the use of native species in all remedial projects.
- Prevent and control the spread of undesirable exotic species.
- Educate the public to integrate the values of wildlife in economic development.
- Meet the restoration needs of wildlife communities.

The goals of the TWCC will be met when:

- There is a diverse, healthy, and sustainable native wildlife community in the Lake Superior basin.
- There is a wildlife community-based program to monitor the health of ecosystems in the Lake Superior basin.
- Species at risk/concern (federally threatened and endangered) are recovered.

The current status and health of terrestrial wildlife communities is a reflection of the landscape, its habitat and environmental quality, and human-imposed regulations and actions.

Mammalian populations in the Lake Superior basin have seen greater fluctuations and changes than any other group of terrestrial vertebrates. Many mammalian species, because they have been harvested for food and fur, have seen dramatic changes in community structure and abundance. Some species have become so abundant in certain areas that they are negatively impacting their surrounding environment. Differences in abundance and diversity of species from south to north has led to different management and recovery efforts between Canada and the United States. One of the biggest challenges concerning management of mammals is understanding what mammalian community structure represents a “healthy, sustainable terrestrial wildlife community.”

Birds constitute 71 percent of the vertebrate species found in national forests in the lake states. Because the Lake Superior basin is heavily wooded, the composition, size, and structure of forests strongly affects songbird species diversity, abundance, and productivity. Lake Superior forests provide important habitat for migratory songbird populations, some of which may serve as source populations for other areas. With concerns expressed nationwide over the decline of neotropical migrants, the Lake Superior basin should be a critical region for migratory songbird conservation.

Until 10 to 15 years ago, **amphibians and reptiles** were seldom considered in management and conservation efforts. As a result, historical population data is mostly incidental. Species ranges are often created from museum collections and records. Since scientists worldwide began focusing on declining amphibian populations in the early 1990s, new efforts to monitor populations and to study the effects of anthropogenic influences have given us an increased awareness and concern for amphibian and reptile communities.

About 90 percent of the nearly one million species of animals in the world are terrestrial or aquatic **invertebrates**. Insects are the most diverse group of invertebrates and globally may have the largest collective biomass of all terrestrial animals. Yet, within the Lake Superior basin, little information is available on the status and trends of the insect or terrestrial invertebrate populations.

Green plants form the base for all animal life, but protection of plants has seldom been associated with the protection of terrestrial wildlife. The term ‘wildlife’ has traditionally been used to refer to animals only. It is evident from the long list of rare and endangered plants in the Lake Superior basin that for every threatened animal there are two or more endangered plants. The importance of plants to the survival and well being of animals must be recognized and factored into the equation of wildlife conservation.

The role of **soil invertebrates, fungi, and microorganisms** in the ecosystem needs to be better understood. Interdependencies of every part of the biotic community, including the decomposers, must be taken into account. Very little information is currently available, and new research must be initiated in this area.

Habitat changes have a significant impact on terrestrial wildlife. Nearly eighty-five percent of the land in the Lake Superior basin is forested. Current forest management practices have resulted in a mosaic of many small stands of widely different age classes. Temporary edges are abundant, and large blocks of unbroken mature mesic forest are rare. Fire as a natural process is rare and is not currently used as a management tool in most areas. Degradation and loss of wetland habitat caused by eutrophication, pollution, scouring, addition of non-native fish, and loss of surrounding upland habitat affects species dependent on wetland habitats. Habitat fragmentation and destruction, compounded by pollution of some of the otherwise suitable habitat, as well as loss of the corridors between suitable areas and loss of plant diversity due to invasion of exotic species, all may have a devastating impact on the viability of wildlife communities.

Environmental quality also plays a significant role in the health of wildlife communities. Environmental contaminants from toxic chemicals that humans introduced into the environment in the mid-1900s nearly eliminated top carnivores such as bald eagles and cormorants. Populations of some of the affected species have recovered well, but these chemicals cause health problems that include reduced hatching success, eggshell thinning, abnormal adult behavior, deformed embryos and hatched young, biochemical changes, endocrine disruption, and suppressed immune function.

Direct human interference, including harvest and management of selected species, has caused dramatic changes in wildlife communities over the past 150 years. Many mammalian species have been stressed by overharvest. For the species that are of interest to hunters and trappers, management programs have traditionally focused on providing populations for harvest and not on the overall ecosystem. But ecosystem management is now being tested and used by agencies and organizations throughout the basin. This has begun to create a focus on all wildlife species.

To achieve a healthy ecosystem that includes a healthy terrestrial wildlife community, human-caused stresses must be managed. To achieve such management, people who live in and use the Lake Superior basin must understand and value healthy wildlife communities.

National, state, county, and local public land units currently plan management strategies independently, but development of ecologically sound, cost-effective techniques that encourage natural processes on the forest landscape will require partnerships with the forest landowners, including the forest industry.

Actions

The following **strategies** are recommended in order to meet the mission and goals for terrestrial wildlife in the Lake Superior basin:

A. Develop action-oriented regional and watershed-scale management plans. Support the implementation of protection and restoration actions recommended in these plans.

B. Encourage land use planning efforts that are targeted at protecting and restoring wildlife while also maintaining economic viability of local communities.

C. Foster an understanding of the relationship between individual (personal, organizational, and government agency) land use decisions and cumulative effects on ecosystem integrity. Compile Best Management Practices that are conducive to sustainable terrestrial wildlife.

D. Implement actions that consider all ecosystem components in planning and implementation. Demonstrate positive results of basinwide, landscape-scale, intergovernmental planning and collaboration.

E. Support contaminant load reduction efforts, track contaminants within “best bet” wildlife species, and encourage the development of biological indicators for air quality monitoring.

F. Inventory all levels of the biotic community, assess wildlife needs and develop actions for protection, maintenance, and restoration, with priority attention to groups for which little is known (gaps).

G. Inventory extent of exotic, invasive terrestrial wildlife species and implement actions to prevent, remove, or control them in the Lake Superior basin.

H. Develop, test, and implement monitoring protocols, sampling procedures, and data handling for identified high priority "best bet" indicators. Network this monitoring and compile the information long-term and basinwide.

I. Beyond "best bet" indicators, develop an integrated, community-based wildlife program to monitor ecosystem health.

J. Conduct assessments and implement conservation strategies for important terrestrial wildlife species and communities.

K. **E**valuate restoration projects and restoration ecology research that addresses terrestrial wildlife in order to link successes to specific restoration features and future needs.

L. Protect, enhance, and restore species of concern such as caribou, moose, colonial waterbirds, boreal owl, northern goshawk, white pine, and hemlock.

M. Encourage the use of native species for all projects requiring vegetation restoration.

N. Identify population issues and implement recovery actions for threatened and endangered species.

The **priority projects** listed in Figure 7-1 were selected to provide a range of opportunity with an emphasis on an ecosystem approach. The projects identified focus on collaborative efforts, non-traditional species, and species for which little is known. Many of these needs have not been well-funded historically, yet they make up significant components of our Lake Superior basin ecosystems.

Figure 7 -1. Action Summary

Project	Lead Agency/Funding Source	Funded	Needs Funding
Watershed Analysis and Restoration	Lake Superior NF's, with partners including MN DNR, MI DNR, WI DNR, GLIFWC, Tribes, etc.		X
Bayfield Peninsula Binational Program Demonstration Project	USFWS, DU, USFS, NPS, GLIFWC, Red Cliff Band of LSC, local governments, private landowners, The Nature Conservancy (TNC), others		X
Upper Peninsula of Michigan Coastal Wetland Project	USFWS, DU, MI DNR, KBIC, BMIC, GLIFWC, TNC, WPBO, Village of L'Anse, Ottawa NF, NRCS, Private Landowners, UPRCD	X	X
Superior Coastal Wetland Initiative	USFWS, Bad River Band of LSC, Red Cliff Band of LSC, WI DNR, TNC, DU, TU, Douglas, Bayfield, Ashland, Iron counties Land Conservation District, NRCS, landowners, GLIFWC, Chequamegon Chapter of the Audubon Society	X	X
Determine the Status and Levels of Toxic Chemicals in Colonial Birds within the Lake Superior basin	NPS, USGS-BRD, MN DNR, WI DNR, MI DNR, USFWS, Pukaskwa National Park, OMNR, CWS, Parks Ontario, EC		X
Determine the Status and Trends of Amphibians within the Lake Superior basin	NPS, USGS-BRD, USFWS, WI DNR, MN DNR, MI DNR, Milwaukee Public Museum, NRRI, OMNR, CWS, USFS		X
Determine the Status and Trends of Breeding Birds within the Lake Superior basin	NPS, USFS, USGS-BRD, USFWS, NRRI, OMNR, CWS		X
Non-vascular Plants, Invertebrates, Fungi, and Micro-organisms Inventory/Analysis	Lake Superior NF's, MN DNR, MI DNR, WI DNR, GLIFWC, Tribes, etc.		X

Figure 7 -1. Action Summary

Project	Lead Agency/Funding Source	Funded	Needs Funding
Invasive Plant Species Inventory and Eradication	Ottawa NF, Northwoods Weed Council (Ottawa NF, Chequamegon Nicolet NF, Hiawatha NF, Apostle Islands NL, TNC, GLIFWC, LCO Tribe, WI DNR)		X
Implement High Priority "Best Bet" Monitoring	All federal, state, and provincial agencies, GLIFWC, Tribes, and First Nations within the LSB.		X
Survey for Ecosystem Approaches to Wildlife Community Monitoring	TWCC, GLIFIWC, USFS, NPS, USGS BRD, NRCS,		X
Conservation Assessments, Strategies, and Implementation for Wildlife Species	Lake Superior NF's, MN DNR, MI DNR, WI DNR, GLIFWC, Tribes		X
White Pine Regeneration	USFS, Gunflint RD, FSL Rhinelander, WI DNR, MN DNR, WPS		X
Native Plant Restoration - Nursery Production	J.W. Toumey Nursery, Ottawa NF, MI DNR, GLIFWC, Tribes		X
Kirtland's Warbler Recovery	USFWS, MI DNR, others	X	

7.0 ABOUT THIS CHAPTER

The Terrestrial Wildlife Communities chapter of the Lake Superior LaMP 2000 consists of several elements. The mission, principles, and goals of the Binational Program for terrestrial wildlife communities are presented in Sections 7.1, 7.2, and 7.3. Section 7.4 describes healthy terrestrial wildlife communities. Section 7.5 summarizes characteristics of the Lake Superior basin as they relate to terrestrial wildlife communities. Section 7.6 provides the status and trends of terrestrial wildlife communities. Sections 7.7, 7.8, and 7.9 describe the most significant needs facing the terrestrial wildlife communities, strategies for meeting the mission and goals for terrestrial wildlife communities, and the next steps toward implementing these strategies.

7.1 MISSION

The mission of the Binational Program for Terrestrial Wildlife Communities is to support a diverse, healthy, and sustainable native wildlife community in the Lake Superior basin. Terrestrial wildlife includes plants, animals, and associated microorganisms.

7.2 PRINCIPLES

Several principles were developed by the Terrestrial Wildlife Community Committee to guide the work of the Binational Program. They are:

- Encourage disturbances that are within natural variation.
- Manage land and wildlife populations using practices that mimic natural variation.
- Understand the relationship between wildlife and disturbance (both anthropogenic and natural).
- Keep wildlife species free of contamination.
- Encourage the use of native species in all remedial projects.
- Prevent and control the spread of undesirable exotic species.
- Educate the public to integrate the values of wildlife in economic development.
- Meet restoration needs of wildlife communities.

7.3 GOALS

The Binational Program for Terrestrial Wildlife Communities is working toward the following goals:

- There is a diverse, healthy, and sustainable native wildlife community in the Lake Superior basin.
- There is a wildlife community-based program to monitor the health of ecosystems in the Lake Superior basin.
- Species at risk/concern (federally threatened and endangered) are recovered.

7.4 HEALTHY TERRESTRIAL WILDLIFE COMMUNITIES

7.4.1 Natural Processes of a Healthy Ecosystem

For an ecosystem to be considered healthy, the following natural processes must function well:

- Natural disturbances are taking place (such as flooding of riparian zones, openings created by wind or fire).
- Native wildlife are producing young and remaining genetically viable.
- Energy is flowing to all trophic levels historically found in the habitat.
- Plant and animal communities have good diversity of native species.
- Populations of plants and animals are fluctuating in natural cycles relative to one another.

7.4.2 Human-Induced Processes

Certain human-caused stresses must be managed to recreate a healthy ecosystem.

- Contaminant levels in plants and animals are sufficiently low, so they do not negatively affect the life cycles of species, nor do they negatively affect human health.
- Exotic species of plants and animals, especially those that are harmful or invasive, are either eliminated, or are reduced to the point that biodiversity of the native community is not impaired. (Non-native species are considered exotic species; invasive species are those that are introduced into an area, and become either the most or one of the most abundant species within a short period of time.)
- Species of concern, especially threatened and endangered species, are recovered and are no longer in jeopardy.
- Human uses of our natural resources, including timber harvest, agriculture, recreation, mineral extraction, fish and wildlife harvest, energy generation and use, and construction of new dwellings, are done in an ecologically sustainable manner.
- Land management practices mimic natural disturbance.
- Forest habitats represent all age classes in blocks of various sizes, including large blocks of mature forest.

7.4.3 Definition of a Healthy Terrestrial Wildlife Community

The Terrestrial Wildlife Community Committee is focusing on one piece of the Lake Superior ecosystem, working concurrently with the other committees of the Lake Superior Binational Program. Together, implementation of each committee's recommendations will improve the health of the ecosystem.

The Terrestrial Wildlife Community Committee recognizes that its piece of the ecosystem (terrestrial wildlife) has processes that must function well to be considered a "diverse, healthy, and sustainable native wildlife community in the Lake Superior basin." These processes include:

- Genetic diversity is maintained at the population and individual level

- All indigenous species are present, or if not present, the habitat exists to rehabilitate or restore extirpated species
- Predator and prey interactions are intact and in balance over the long-term
- Populations fluctuate in natural cycles relative to one another
- Energy flows naturally from one trophic level to another
- No populations are so high (such as white-tailed deer) that they impact other populations in a negative, long-term manner
- Enough healthy young are produced to result in sustainable populations

As with ecosystems, human-caused stresses must be managed to recreate a healthy terrestrial wildlife community. The Terrestrial Wildlife Community Committee also believes that in order for this healthy ecosystem and terrestrial wildlife community to become a reality, people living in and using the Lake Superior basin must understand the value of healthy wildlife communities.

Figure 7-2. Lake Superior Basin

7.5 LAKE SUPERIOR BASIN

7.5.1 Historical

Native American Influence. Native Americans influenced terrestrial wildlife communities through habitat manipulations and harvests. Harvest of beaver and large ungulates could have indirectly affected the forest community through reduction in browsing and lowland flooding (Stearns 1995). The effects, however, were likely localized and minor and have never been quantified (Stearns 1995).

Fur Trade. The first white explorers and settlers were attracted to the Lake Superior basin by the abundance of furbearing animals. A series of forts and settlements were established along the Great Lakes to protect the fur trade (The Nature Conservancy [TNC]1994). Many populations of furbearing mammals were depleted as a result of unregulated fur harvest. Once the stocks were depleted, the fur trade moved west to more productive areas.

Logging. On the U.S. side of the basin, the forests were almost entirely cut-over between the mid-1800s and early 1900s. Early logging concentrated on white pine; individual trees could reach 200 feet in height and produce 6000 board-feet of lumber (TNC 1994). Red pine were harvested to a lesser extent. Early logging practices greatly reduced the seed source for many of the conifer species. In addition, burning of the slash from timber harvest further eliminated reproduction. Hemlock was removed during a later wave of logging when the bark was used for the tanning industry (WI DNR 1995).

After railroads and logging roads were built, hardwoods were harvested by both clearcutting and high-grading (cutting only the most valuable trees). Many hardwood species regenerated, especially sugar maple, beech, basswood, yellow birch, and ash.

Clearing of presettlement forests not only eliminated the forest ecosystem locally and regionally, but it also created other massive problems when cut logs were floated down the closest stream for transport to Lake Superior or other locations. Riparian vegetation was removed, stream banks were trampled, and stream bottoms were scoured or disrupted. The loss of vegetation created erosion of soils and sheet run-off into streams. Water quality was degraded, and fish habitat was often lost (TNC 1994).

In the Canadian boreal forest, logging began later than in the U.S. portion of the Lake Superior basin, mostly because the forest contained fewer timber-quality trees. The trees were harvested mostly for pulpwood (National Wildlife Federation [NWF] 1993).

In a 1993 report, the National Wildlife Federation predicted that the forest product industry is the most likely sector to grow and have an impact on biodiversity and ecosystem health in the Lake Superior basin.

Settlement. After the presettlement forests were cut-over, some of the land was completely cleared and leveled for agriculture. However, most of the forest lands were unsuitable for farming and were later abandoned (Stearns 1995). Abandoned farm fields have grown back to trees, were planted to trees, or have become dominated by brush. Areas with productive soils remain in agricultural production today, dominating the landscape in localized areas (such as old lake plains). However, agriculture only dominates about one percent of the landscape in the Lake Superior basin. Agricultural practices have contributed to the loss of wetlands by draining or filling to level fields. Some of the most toxic and persistent chemicals used in the mid-1900s were agricultural-based.

Most human habitation and urban structure is focused on or near the shoreline of Lake Superior. The largest communities in the basin— Duluth, Superior, Marquette, Thunder Bay, and Sault St. Marie—are located directly on Lake Superior. Shoreline development continues today, but the focus has changed from industry toward housing and recreational development. This development creates more roads and infrastructure, hardens shorelines, and causes a loss of vegetation.

Since the mid-1800s, mining has had a major impact on the economics and natural resources of the basin. During the 1870s, the Silver Islet mine east of Thunder Bay was the world's most productive silver mine. It closed in the early 1880s. The Keweenaw Peninsula in the Upper Peninsula of Michigan was the world's leading producer of copper during the early 1800s. One of the largest Superfund sites in the country is a result of this copper mining (NWF 1993). Iron ore mining in Minnesota began in 1884 on the Vermilion Range and in 1892 on the Mesabi Range. The eastern portion of the Mesabi Range is within the Lake Superior basin. Mining of taconite, a lower-grade iron ore, continues on the Mesabi Range, and Minnesota remains the largest producer of iron ore and taconite in the United States. In Wisconsin, brownstone was quarried in the late 1800s to early 1900s. Approximately 12 quarries were mined, and the brownstone was exported to large cities in the United States, including Chicago, St. Louis, and Minneapolis/St. Paul. Brownstone buildings remain in the basin in Wisconsin, but brownstone is no longer quarried. Old, unreclaimed quarries dot the landscape.

One of the unique characteristics about the Lake Superior basin is that much of the land is in public ownership. In Ontario, about 95 percent of the basin is in public ownership, consisting of federal and provincial parks and crown (provincial) land. In the United States, about 25 percent of the basin is in public ownership under the jurisdiction of federal, state, and county governments (NWF 1993).

Transportation. By the early 1830s, the Great Lakes were opened to international shipping with the completion of several canals that connected all the Great Lakes to the St. Lawrence Seaway. This allowed commodities harvested from the Lake Superior basin to be exported to growing cities farther east. Many cities on Lake Superior had burgeoning shipping industries in the late 1890s and early 1900s, but only a few major shipping docks now remain, including those at Duluth-Superior in the United States, and at Thunder Bay, Marathon, and Sault Ste. Marie in Ontario.

Railways created additional accessibility and were important for transport of harvested hardwood timber, which was not readily transported by water. Numerous railroad companies and railroad spurs were prevalent in the late 1800s and early 1900s, providing transportation to and from the region.

Recreation. The forests, streams, and lakes of the Lake Superior basin have attracted outdoor recreation enthusiasts throughout the 20th century. Since the mid-19th century, resorts and lodges have housed visitors from metropolitan areas who come for hunting, fishing, boating, camping, and other outdoor pursuits. Outdoor recreation interest remains high today and is increasing in popularity, especially in areas within driving distance of metropolitan centers, such as Minneapolis/St. Paul. Recreation pursuits have expanded to include skiing, snowmobiling, all-terrain vehicle riding, hiking, bicycling, wildlife watching, sailing, and others. Facilities for these activities have been developed in response to the interest and need.

7.5.2 Habitat

The habitat chapter (Chapter 6) of this LaMP provides detailed information about habitat status and trends in the basin. Land use/land cover in the Lake Superior basin is shown in Table 7-1. A significant majority of the land is in forest cover (84.4 percent). The remainder of land cover is developed, bare ground (which includes mines), grassland, and agriculture.

Table 7-1 1998 Land Use/Land Cover in the Lake Superior Basin (including Canada and U.S.)

Land Use/Land Cover	Percent of Basin
Developed	0.3
Agriculture	1.2
Grass/brush	4.4
Bare ground	0.5
Conifer	35.2
Conifer/Hardwood	22.8
Hardwood	25.2
Hardwood, early seral	1.2
Water	7.3

Source: Natural Resources Research Institute, University of Minnesota, Duluth, 1998.
Note: The data were compiled from satellite imagery and do not add to 100 due to cloud cover and missing data.

The conservation and management of forests in the Lake Superior basin will have a significant impact on terrestrial wildlife. The Wisconsin Department of Natural Resources (WI DNR) (1995) projected the following trends for northern forest management in Wisconsin:

- The total forested area will probably remain the same or increase slightly.
- Aspen-birch type forest will gradually decrease as forest succession progresses. The area in aspen has declined 1.8 million acres since 1936.
- Portions of current aspen-birch forests will be replaced by various mixtures of white pine, red maple, and locally, red oak. A significant proportion will succeed to mixed stands of mesic hardwoods, with sugar maple playing the largest role.
- All forests currently dominated by mesic hardwoods will remain so, but species composition will vary greatly depending on geographic location, site type, and management practices. Sugar maple will become more dominant on many mesic sites.
- Red pine plantations are likely to dominate local areas, particularly on forest industry lands. Jack pine acreage is decreasing, while acreage of red pine plantations is increasing.
- Because of great disparity between economic and biological maturity of most tree species, an increase in old-growth forests, in a biological sense, is unlikely. Increased utilization prevents development of old-growth characteristics in managed mature forests.
- Clearcuts and plantations will continue to fragment large, uniform blocks of mature mesic hardwoods. Temporary edges caused by forest cutting will continue to dominate the northern landscape.
- Small, permanent grassy openings will continue to decline to less than 1 percent of public and forest industry lands. Wildlife that are dependent on grassy, open areas will decline.
- Balsam fir and tag alder will continue to dominate the former white cedar forests. White cedar and Canada yew reproduction will be restricted to scattered, local areas.
- The scattered relict stands containing hemlock and yellow birch will continue to decline. Reproduction of these species will be restricted to scattered, local areas.
- Fire will not play a significant role as an ecological agent in the northern forest.
- Road networks will continue to be improved and expanded.

The demand will continue to increase for forest products such as pulpwood and sawlogs, game species such as white-tailed deer and ruffed grouse, and aesthetic characteristics such as wild country and solitude.

The WI DNR also made the following observations. Under current management practices, only selected economic tree species, a few forest game species, and selected endangered or threatened species receive funding and management attention. The result is a mosaic of many small stands of different forest age classes. Temporary edges are abundant. Large blocks of unbroken mature mesic forest are rare. Fire as a natural process is rare and is not currently used as a management tool in most areas. National, state, county, and local public land units currently plan management strategies independently, but development of ecologically sound, cost-effective techniques that encourage natural processes on the forest landscape will require partnerships with the forest landowners, including the forest industry. Public pressure to pay more attention to maintaining complete and functional forest ecosystems will surely continue.

7.5.3 Sociological

Specific population and sociological trends are provided in the sustainability chapter (Chapter 9) of this LaMP.

Pursuit of wildlife-related recreation is important for residents of the basin. In 1996, Michigan had the highest number of hunters of all states in the United States, with 934,000 (U.S. Dept. of Interior and U.S. Dept. of Commerce 1998). This was an increase from 1991, when 826,000 people hunted in Michigan (U.S. Dept. of Interior and U.S. Dept. of Commerce 1993). In 1996, Wisconsin was fourth in the United States with 665,000 hunters, which was a decrease from 747,000 in 1991 (U.S. Dept. of Interior and U.S. Dept. of Commerce 1998, U.S. Dept. of Interior and U.S. Dept. of Commerce 1993). The total number of days that Ontario residents spent on non-consumptive wildlife-related recreation increased from 1981 to 1991, but the total number of days spent hunting decreased (Filion and others 1993).

Wildlife watching is important to both residents and nonresidents of the basin. In 1991, more than 7 million Ontario residents aged 15 years and over (91.9 percent of the population) participated in one or more wildlife-related activity (Filion and others 1993). In 1996, almost $1.6 billion was spent in Wisconsin for wildlife watching, the fifth-highest in the United States. Michigan supported slightly more than 16 million days of nonresident wildlife watching, which was second in the nation (U.S. Dept. of Interior and U.S. Dept. of Commerce 1998).

Economic conditions play a large role in recreational use of the Lake Superior basin in the United States. As young, active people are employed, they gain disposable income but lose time for outdoor recreation pursuits. This often creates a demand for recreational opportunities that are closer to home and provide immediate gratification. Also, continued population growth in Chicago and the Minneapolis/St. Paul metropolitan areas will further contribute to the demand for outdoor recreation in the northern regions of Michigan, Wisconsin, and Minnesota (WI DNR 1999).

Access to quality outdoor activities has influenced land and home acquisition. The trend of private owners buying land and/or second homes/cabins is increasing, especially near Lake Superior and on inland lakes. In the United States, this trend is greatest along the North Shore of Lake Superior in Minnesota and the Bayfield Peninsula in Wisconsin, largely because they are within a half-day drive from large metropolitan areas. For example, Bayfield County in Wisconsin, which has more than half its land base in the Lake Superior basin, has seen significant land price increases in the last few years. Equalized property values increased 21.64 percent from 1998 to 1999, which was the second highest increase in Wisconsin (Wisconsin Department of Revenue 1999). This trend is slower in the Upper Peninsula of Michigan. In Ontario, this trend is greatest along the shorelines east and west of Thunder Bay and north of Sault Ste. Marie. Development is not yet as extensive as along the North Shore of Lake Superior in Minnesota.

This increased demand for land, especially along rivers and lakeshores, creates further stress on the landscape. An increase in habitat fragmentation is often the result. Shoreline habitats, both upland and aquatic, lose much of their biodiversity value as they become developed (Gillum and others 1998).

7.5.4 Land Use and Economics

The sustainability chapter (Chapter 9) of this document provides detailed economic information about the Lake Superior basin. General information that directly relates to terrestrial wildlife is included here.

In general, family and household incomes in Lake Superior counties in the United States are well below the national and state medians (1979 and 1989 data). In 1990, average monthly mortgage payments within the watershed were considerably below those in the U.S. and the respective states, indicating slow or little economic growth.

The three principal industries in the Lake Superior basin are forestry/forest products, mining, and tourism (NWF 1993).

Land cover on the Canadian portion of the basin is 98.7 percent forests, and most of this is in public ownership (National Wildlife Federation 1993). It is mostly boreal forest of black spruce, white spruce, balsam fir, jack pine, aspen, and birch. Maple is found in the eastern portion of the watershed. Administration of natural resources in Ontario (including forestry, fish and wildlife, and public lands) is the responsibility of the OMNR. Portions of two OMNR Regions and five OMNR Districts are found within the basin. District offices coordinate the local field delivery of OMNR programs including forest management planning and fish and wildlife inventories and allocation. Forest management occurs on a number of forest management units under Sustainable Forest Licenses across the commercially harvested Crown forests of Ontario. Individual Forest Management Plans are prepared by the forest management companies, in conjunction with OMNR staff, every 5 years. The 2-year planning process involves a great deal of public and stakeholder consultation and is aimed at ensuring that sustainable forest management occurs. Planning and management follows an ecosystem approach in which timber harvesting attempts to follow natural disturbance patterns (e.g. fire) and retain important wildlife habitat features such as snags and winter habitat.

Eighty seven percent of the land in the U.S. portion of the basin is forested (National Wildlife Federation 1993). Ownership patterns of forest land in the U.S. portion of the basin are shown in Table 7-2.

Table 7-2 Forest Land Ownership Patterns for Lake Superior Basin in the United States

Landowner	Percentage
National Forest	18
Other Public Owners	29
Forest Industry	15
Private and Other Owners	38

Source: National Wildlife Federation 1993

Forty-seven percent of the timberland is in public ownership, which includes lands managed by the federal government (U.S. Forest Service), states (Departments of Natural Resources), and counties. The remainder is owned by the forest industry and private landowners. The U.S. Forest Service has a multiple-use mandate and follows a planning process that directly involves the public. State Natural Resources Departments and County Forestry Departments are beginning to encourage public involvement in their forestry planning. All lands, however, are open to recreation. Coordinated regional planning is seldom, if ever, done; however, the Wisconsin and Minnesota Departments of Natural Resources recently initiated a land use planning effort for the northwest sands region (locally referred to as the pine barrens), which is located on the edge of the Lake Superior basin. They are involving as many stakeholders as are interested, including towns, counties, landowners, the forest industry, and non-profit organizations.

Mining is currently one of the other major land uses. Interest in mining and manufacturing is increasing in the basin. In 1984, one of the world's largest gold deposits was found near Marathon, Ontario. Currently, there are four active gold mines in that area. Two smaller gold mines are located near Wawa. A platinum-palladium mine is located approximately 100 km north of Thunder Bay, and zinc/copper mines are located in Manitouwadge and Schreiber. The Schreiber mine is slated for closure.

Approximately three-fourths of United States iron ore is produced in Minnesota, totaling about 40 million tons per year (NWF 1993). Most of the ore is shipped to Great Lakes steel mills. One active iron ore mine is located near Ishpeming, Michigan. A large copper mine and smelting operation in Ontonogon in the Upper Peninsula was recently closed. On the Canadian side, the major iron ore-producing mine was located in Wawa. This mine produced ore from 1960 until its closure in May 1998, supplying material to the Algoma Steel mill in Sault Ste. Marie, which is still in operation.

There are currently five large and two medium-sized pulp and paper operations and four large, two medium, and four small sawmill operations located within the basin on the Ontario side. In addition, there are two veneer mills and two oriented strandboard/particle core board mills within the basin in Ontario. Four pulp and paper mills are found on the U.S. side of the basin, two in Minnesota and two in Michigan. Several mills located outside of the basin draw pulpwood from the basin's forests. A paper mill in Ashland, Wisconsin, closed in 1998.

Tourism in the Lake Superior basin is related to outdoor recreation opportunities. A significant draw is the large percentage of public lands and trails available for public use. Public lands that are set aside as parks include national parks such as Apostle Islands National Lakeshore in Wisconsin and Pictured Rocks National Lakeshore in Michigan, provincial parks such as Pukaskwa National Park in Ontario, and state parks and natural areas such as Split Rock Lighthouse State Park in Minnesota. These areas not only provide outdoor recreation opportunities, but they also protect important habitats for wildlife and provide opportunities for natural resource management that are not commodity-based. Local communities that serve as gateways to these protected areas and trails gain economic development opportunities by serving tourists and residents.

7.6 STATUS AND TRENDS OF TERRESTRIAL WILDLIFE

7.6.1 General

Habitat changes on the landscape, as well as harvest and management of select species, have created some dramatic changes in wildlife communities over the past 150 years. Table 7-3 provides an example of how some species and bird communities have changed since European settlement. Populations have fluctuated from common to rare or from rare to common, and community structures have shifted as a result of large-scale logging in the late 1800s and early 1900s. Species such as the gray squirrel, porcupine, and beaver were rare in the early 1900s, but populations increased as the forest began to mature. Other species, such as raccoon, eastern cottontail, and striped skunk became more abundant as young forests, forest edges, resorts, small towns, and agriculture provided favorable habitat. Birds such as ruffed grouse and woodcock increased as young forests became available. However, forest bird species, such as the pine warbler, barred owl, and scarlet tanager, decreased in numbers as forests were converted to brushlands; current trends from young to mature forests are again providing habitat for these species (Wisconsin Department of Natural Resources 1995).

Table 7-3. Changes in the Relative Abundance and Distribution of Selected Wildlife in Wisconsin's Northern Forests: 1850-1994

	Relative Abundance and Distribution			
Species	**Mid-1800s**	**Early 1900s**	**Mid-1900s**	**1994**
White-tailed deer	Low Clumpy	Low Clumpy	Abundant Continuous	Common Continuous
Coyote	Low Clumpy	Common Clumpy	Abundant Continuous	Common Continuous
Bobcat	Low Clumpy	Low Clumpy	Common Continuous	Rare Continuous
Moose	Low Clumpy	Rare Isolated	Gone Gone	Rare Isolated
Snowshoe hare	Low Clumpy	Common Continuous	Abundant Continuous	Low Clumpy

Table 7-3. Changes in the Relative Abundance and Distribution of Selected Wildlife in Wisconsin's Northern Forests: 1850-1994

	Relative Abundance and Distribution			
Species	**Mid-1800s**	**Early 1900s**	**Mid-1900s**	**1994**
Timber wolf	Common Continuous	Common Continuous	Gone Gone	Rare Clumpy
Fisher	Common Continuous	Rare Isolated	Gone Gone	Common Continuous
American marten	Abundant Continuous	Rare Isolated	Gone Gone	Rare Isolated
Elk, wolverine	Low Clumpy	Gone Gone	Gone Gone	Gone Gone
Bald eagle, osprey	Common Common	Common Continuous	Low Clumpy	Common Continuous
Ruffed grouse	Low Clumpy	Common Continuous	Abundant Continuous	Common Continuous
Woodcock	Low Clumpy	Common Clumpy	Abundant Continuous	Common Clumpy
Sharp-tailed grouse	Low Clumpy	Abundant Continuous	Common Clumpy	Rare Isolated
Beaver	Common Continuous	Rare Isolated	Low Clumpy	Abundant Continuous
Grassland birds	Rare Isolated	Common Continuous	Common Clumpy	Rare Isolated
Young-forest birds	Rare Isolated	Common Clumpy	Common Continuous	Common Continuous

Source: Wisconsin Department of Natural Resources 1995
In order of abundance, from least to most abundant: gone, rare, low, common, abundant.
In order of distribution, from extirpated to widely distributed: gone, isolated, clumpy, common, continuous.

Direct human interference and harvest also dramatically affects species abundance. Species that rely on large blocks of wild land with little human presence, such as timber wolf, Canada lynx, wolverine, and spruce grouse, were extirpated from a portion of their range (WI DNR 1995). Some of these species can be recovered with careful management and reintroduction. Many species were harvested or exploited until they nearly disappeared from the basin. For example, herring gull populations in the early 1900s were almost extirpated from the entire Great Lakes basin as a result of persecution at nesting sites and demand for bird feathers for the millinery trade during the late 1800s. The Migratory Bird Convention of 1916 provided protection, and herring gull populations began to increase in the 1940s (Ryckman and others 1997).

Environmental quality also plays a significant role in wildlife communities. Environmental contaminants from toxic chemicals that humans introduced into the environment in the mid-

1900s nearly eliminated top carnivores such as bald eagles and cormorants. The effect of chemical pollutants on amphibian populations has also been noted. Species such as bald eagle, herring gull, and river otter are indicators of the quality of the environment, and some monitoring is taking place in the basin to determine contaminant levels and their effects.

The landscape, its environmental quality, and human-imposed regulations and actions are reflected in the current status and health of terrestrial wildlife communities. Tough decisions are being made and will need to be made in the future regarding restoration and management of terrestrial wildlife. As a society, we have begun to understand what needs to happen in the Lake Superior basin to provide a native, healthy, sustainable wildlife community. But there is also much we don’t know. Adaptive management and strategic decision-making may aid in moving toward our goals.

The following summaries are provided for groups of species: mammals, birds, amphibians and reptiles, invertebrates, and plants. We generally provide a broad overview of changes that have taken place in these communities and their current status. Some larger groups are broken down into smaller groups of species, depending on our knowledge. Information on federally threatened and endangered species is also provided, but the reader will be referred to the habitat section for more detailed information. Information on species that are considered rare to the Lake Superior basin is also provided in the habitat section of this LaMP.

The status and trend information helps to define the overall problems and opportunities for terrestrial wildlife communities in the Lake Superior basin and to define broad strategies for the Binational Program and its partners.

This work is not a detailed account of status and trends of all wildlife in the Lake Superior basin. There are two reasons for this. First, the time frame given to the working committees was very tight and did not allow for complete compilation of existing data or knowledge. Second, the Binational Program is not a wildlife management entity; rather it is a partnership of agencies from two countries trying to improve the integrity and health of the Lake Superior basin. The work is focused at the strategic level to identify broad goals and strategies. Individuals and organizations may investigate the details at the specific level as they develop and implement programs to meet the Binational Program’s broad strategies.

Because this work was completed in a very tight time frame, gaps may exist in the information presented here. We welcome and encourage feedback concerning those gaps so we can continue to adjust our goals and strategies in an adaptive management mode.

7.6.2 Mammals

7.6.2.1 Status and Trends of Mammals

Mammalian populations have seen greater fluctuations and changes than any other group of terrestrial vertebrates. Furbearers were exploited during the fur trading years, which caused dramatic decreases of most species and nearly wiped out some. Ungulates were hunted for food and hides; carnivores, such as wolves, were feared and harvested to near oblivion in the lower portion of the basin. As regulations were enacted to control the harvesting of such animals, however, many populations rebounded. Wildlife management agencies have successfully reintroduced certain species, such as American marten, to their historic range. Other species, such as white-tailed deer, have become so abundant in certain areas that they may be negatively impacting their environment.

Some species, however, remain in peril. The woodland caribou has been nearly pushed out of the basin. Canada lynx is nearly gone from the southern part of the basin. There is very little we know about the trends of many small mammals, such as voles, mice, and bats, mostly because they are not harvested by humans for game or food.

There are differences in abundance and diversity of species from south to north. Many of the species that were lost in the U.S. portion of the basin in the early 1900s persisted in the Canadian portion. Species such as white-tailed deer moved into the Canadian portion of the basin in the late 1800s. Because of these differences, habitat and population management and recovery efforts are different between Canada and the United States. For example, Ontario is managing habitat to protect woodland caribou and needs to understand and monitor the effect that deer, moose, and wolf have on caribou. The states have and continue to actively reintroduce some mammalian species, such as moose, which was not necessary in Ontario. It is unlikely that any work to protect and manage mammalian species has focused on the Lake Superior basin specifically. Most work has been limited by political boundaries. Therefore, no information has been specifically compiled for the basin. This report can provide a starting point.

Ungulates

Within the Lake Superior basin and surrounding area, the ranges occupied by large ungulates (woodland caribou, moose, white-tailed deer, and elk) have been substantially altered from presettlement patterns. Harvesting, human disturbance, and habitat changes have nearly eliminated species such as woodland caribou and elk. Elk have been reintroduced into northern Wisconsin, but they are found nowhere else in the basin. Conversely, white-tailed deer populations in the southern part of the basin are high, largely due to favorable habitat conditions, mild winters, hunting regulations, and decline of natural predators, such as wolf. The white-tailed deer brought with it the parasitic brain worm, which is fatal to both caribou and moose. Minnesota’s moose population has remained relatively stable since the early 1990s (Mark Lenarz, MN DNR, personal communication). Ontario has seen stable to increasing populations of moose since 1992 (Timmermann and Buss 1997). Michigan successfully reintroduced moose into the Upper Peninsula in 1985 and continues to manage the population to increase its range.

Caribou

Woodland caribou historically ranged throughout most of the Lake Superior basin, but they currently can be found only in the northern edge of the basin in Ontario and in remnant populations on islands and in parks (Figure 7-3). Reasons for the decline include hunting, fire, land clearing, logging, increased predation, disease, and human disturbance (Darby and others 1989). In Ontario, timber harvest following European settlement provided a proliferation of woody browse, which allowed moose and deer to thrive. The increased population of moose allowed timber wolf numbers to increase. Although wolves are a natural predator, as wolf populations increased, caribou populations were further stressed. Currently, caribou in northwestern Ontario are found only in areas with major limitations for supporting moose (and wolves) in high densities, unless they can find islands or other forms of refuge where they can exist in a predator-free environment (Godwin 1990). This creates a management scenario where populations of caribou and moose and/or white-tailed deer are not compatible on the same land base because of associated wolf predation and parasitic disease. Addendum 7-A describes efforts to manage and recover this species in Ontario under an ecosystem management approach.

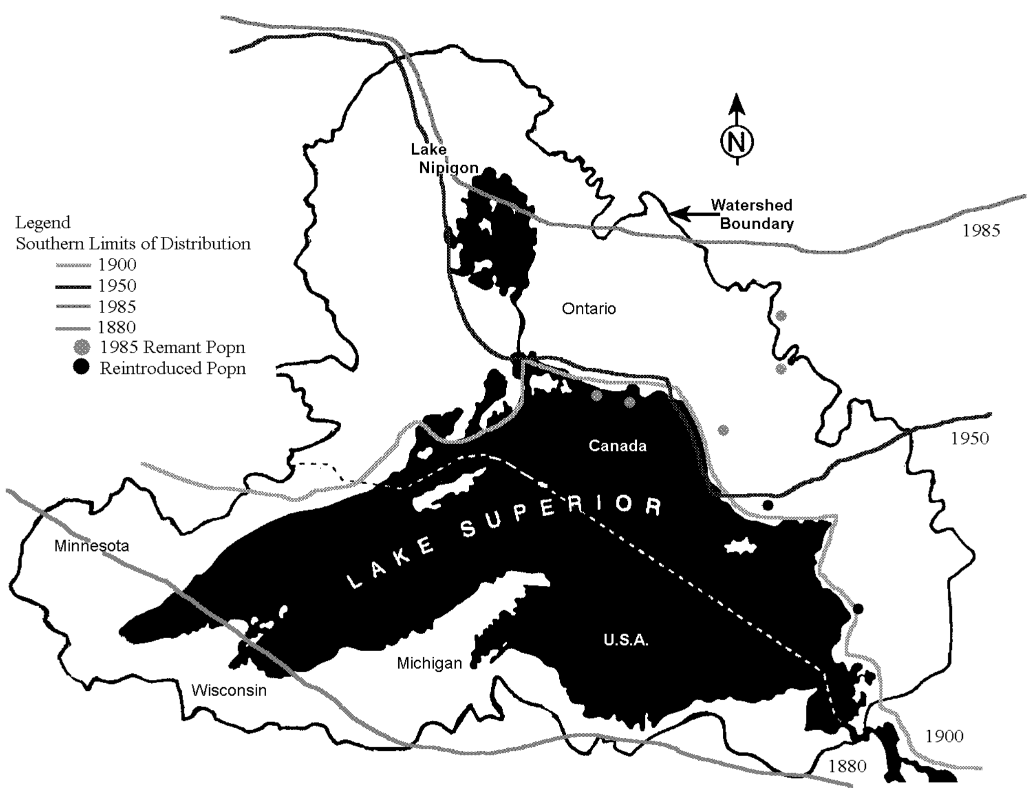

Figure 7-3. Decline of Woodland Caribou Range, 1880 to 1985
Source: Cummings and Beange 1993

White-Tailed Deer

Current deer numbers in the Upper Peninsula of Michigan are estimated to be approximately double the presettlement numbers, based on a habitat suitability model (Doepker and others 1996). Deer moved northward into northwestern Ontario in the late 1890s (Snyder 1938). McCaffery (1995) estimated presettlement populations of deer in northwestern Wisconsin to be approximately 19.5 deer per square mile and peak populations in the 1940s to be 40 to 50 deer per square mile. The 1995 population in northern Wisconsin was about 26.7 deer per square mile, largely due to mild winters and opposition to liberal harvests (McCaffery 1995). Minnesota's deer population increased steadily from 1980 to 1995, but severe winters in 1995-96 and 1996-97 caused the population to decline more than 40 percent. Their numbers have increased in the last few years, however, due to mild winters since 1997 (Mark Lenarz, MN DNR, personal communication). Three primary factors that affect deer numbers in northern Minnesota, in order, are: 1) winter weather, 2) human harvest, and 3) wolf predation (Mark Lenarz, MN DNR, personal communication). A discussion on the ecosystem effects of and approach to deer management is provided as Addendum 7-B.

Increasing numbers of deer have resulted in several impacts to the ecosystem within the basin and elsewhere. Waller and Alverson (1997) suggest that chronically high deer numbers are having substantial, deleterious ecological impacts across many regions. We do not know the overall extent of the problem in the basin, but several studies have shown negative impacts on certain plant species and plant communities in this region (Stoeckeler and others 1957; Frelich and Lorimer 1985; Mladenoff and Stearns 1993; Balgooyen and Waller 1995). Stoeckeler and others (1957) identified a direct negative impact on hemlock seedlings from deer browse in northeast Wisconsin, and Frelich and Lorimer (1985) identified negative effects in the western Upper Peninsula of Michigan. Mladenoff and Stearns (1993) point out that hemlock used to be a regional dominant, but now only occupies 0.5 percent of the landscape. Hemlock requires very specific microhabitat conditions for germination and seedling establishment, and the right conditions occur only in specialized locations. Mladenoff and Stearns agree that deer browsing has a negative effect, but it is only one of many current conditions that suppress regeneration. Climate, dominant forest type (which is now hardwood), and herbivory are all factors that affect hemlock. The ecosystem approach to conservation would require a look at more than deer numbers to reestablish healthy hemlock communities.

Herbaceous plants constitute the bulk of deer summer diets (McCaffery and others 1974), so certain sensitive plants can be negatively affected by deer browsing, especially the species that might be selected by deer as most palatable. In the Apostle Islands and northern Wisconsin, Balgooyen and Waller (1995) showed declines in several woody species, overall herbaceous species diversity, and specific declines in wild sarsaparilla (*Aralia nudicaulis*), Canada mayflower (*Maianthemum canadense*), and blue beadlily (*Clintonia borealis*). The impacts to herbaceous diversity had persisted for over 30 years, with blue beadlily apparently extirpated from Madeline Island.

Other studies have suggested that an overabundance of deer affects other animal species in the ecosystem. In Pennsylvania, for example, a study showed that intermediate canopy-nesting birds declined 37 percent in abundance and 27 percent in species diversity at higher deer densities. Five species completely dropped out at very high densities (38.2 deer/square mile), and two dropped out at highest deer densities (63.8 deer/square mile) (DeCalesta 1994). In New Hampshire, deer were browsing on lupine plants, which are host plants for the endangered Karner blue butterfly (*Lycaeides melissa samuelis*) (Miller and others 1992). This, in turn, decreased populations of the butterfly.

Human interaction with overabundant deer is also seen in increased vehicle collisions, loss of crops and landscape plants, and increased nuisance occurrences.

Furbearers, Including Mid-Sized Carnivores

Beaver, river otter, American marten, bobcat, fisher, mink, and other furbearers were intensively trapped in the mid- to late-1800s, some to the level that they were extirpated from significant portions of the basin. Fishers, for example, were extirpated from Wisconsin and Michigan due to overharvest and habitat destruction (Racey and Hessey 1989a).

Numbers of many furbearers were also severely reduced in Ontario, and species such as beaver, marten, and fisher were extirpated from portions of their historic range. Season closures and other regulations, along with the establishment of a number of Crown Game Preserves in the 1920s, helped reverse the declines and allowed populations to recover. Individual traplines were first established in the 1930s, and in 1950 it became a requirement for traplines to be registered. The registered trapline system, which licensed a trapper to a specific trapping area, stabilized a chaotic industry and allowed distribution of the harvest, eliminated competition between trappers, and encouraged trappers to manage their trapline areas on a long-term basis (Novak 1987). During the period of the 1940s through the 1950s, beaver, marten, and, to a limited extent, fisher, were transplanted from remaining populations to areas of their former occurrence. In 1950 both marten and fisher were generally absent or uncommon in most of the basin. They were common only in the eastern portion of the basin between Wawa and Chapleau (de Vos 1952). Since that time both fisher and marten numbers have increased, and they now reinhabit their former range. In the case of marten, current harvest levels are higher than at any time in over 100 years. Marten in Ontario were also used as source stock for an introduction into the Lower Peninsula of Michigan in 1985 and 1986 (Ludwig 1986).

In Minnesota, raccoon, fisher, American marten, red fox, and black bear populations have all recovered substantially over the past 20 or more years (Bill Berg, MN DNR, Grand Rapids, personal communication). Fisher and marten were closed to harvest in the late 1920s and reopened in 1977 and 1984. Both species have increased their ranges west and south in Minnesota (Bill Berg, MN DNR, Grand Rapids, personal communication). A long series of mild winters and general climate change have allowed many of these species to increase in abundance and range.

Populations of bobcats, fishers, martens and otters can be estimated using a population model developed by Bill Berg of the MN DNR. The model is used widely throughout the Midwest, including Minnesota, Wisconsin, and Michigan. The Wisconsin and Minnesota DNR used the model to estimate populations for their states, and this information is presented below. Unfortunately, little published information is available for population levels of Michigan furbearer species.

Harvest seasons have been established in all three states for otter, bobcat, and fisher. Marten harvest is permitted only in Minnesota. Martens, fishers, and otters have been expanding their ranges in all three states. Martens are designated as a sensitive species by the US Forest Service in the Chequamegon and Nicolet National Forest Land Management Plans.

Beaver

Beaver have increased in abundance and regained a continuous distribution since the trapping-induced population plunge of the early 1900s. The favorable habitat conditions resulting in the overabundance of white-tailed deer have also resulted in record high beaver populations. Beaver impact both the terrestrial and aquatic ecosystems of the basin. When they harvest trees and build dams, they change the aquatic community structure and open riparian canopies, which creates a positive impact to some species and a negative impact to others.

One of the negative impacts of beaver is to the cold water migratory fish communities. Beaver dams create a barrier to anadromous migratory fish that use tributary streams for spawning. In addition, cold water streams in Minnesota's portion of the basin exist and support trout by virtue of climate alone. Summer water temperatures of the surface water driven stream systems are often the limiting factor for healthy fish populations. Riparian forest cover is essential for moderating stream temperature conditions. The removal of riparian forest cover by abundant beaver populations and loss of stream shade results in thermally degraded aquatic trout habitat. Increased water temperatures are also found in ponds above beaver dams.

Bobcat

Bobcat populations in Minnesota are estimated at around 1,500 animals. This population level has been maintained for 20 years. The Wisconsin bobcat population is also estimated at 1,500 animals, which represents a 20 percent increase in population during the past 5 years. Bobcat harvests in all three states range from 100 - 300 animals. These harvests are regulated to provide for a size-stable population.

Fisher

The fisher population in Minnesota has been increasing for about 20 years since the lows of the mid- to late-1970s and is currently estimated to be 10,000 animals. The fisher population in Wisconsin peaked in 1992 at 9,500, declined to 7,500 in 1997, and is now estimated to be nearly 8,000 animals. Both Wisconsin and Minnesota are trying to stabilize the population growth of this species through harvests at about current levels.

Otter

Otter populations in Minnesota, currently estimated at 13,000 animals, have also been increasing for nearly 20 years. The Wisconsin otter population is estimated at 14,000 animals, which represents a decline from the peak population in 1992 of 15,500. Wisconsin harvest regulations were liberalized in 1992 to take advantage of high population levels.

American Marten

American marten are listed as a game species in Minnesota, and a trapping season has been in effect in that state for many years. The population is estimated at 12,000 animals. The marten population has been increasing steadily since 1980 with only small dips when trapping conditions are good and harvests unexpected large. Martens are classified as an endangered species by the State of Wisconsin. They were extirpated from the state in the early 1900s and were reintroduced in the 1970s and 1980s. The marten population continues to be small and isolated, centering around the two release sites. Reasons for the lack of expansion of this species are unknown.

Small Mammals

Small mammals include mice, voles, bats, cottontail rabbits, and snowshoe hares. Little population information is available for any of these species, except perhaps on a site-by-site basis. This group of mammals plays a very important role in providing a prey base for other mammals and birds and for preying on invertebrates.

Threatened and Endangered Mammals

The habitat section of the LaMP provides information about the status of the gray wolf and Canada lynx. Additional information about wolf recovery and status in Canada is provided below.

Gray Wolf

The gray wolf is listed as a federally endangered species in Michigan and Wisconsin, and as a threatened species in Minnesota. It has no special designation in Ontario or Canada.

Recovery programs have been initiated in all three states, and recovery goals are nearly met. The U.S. Fish and Wildlife Service is drafting a proposal to change the status to threatened in Wisconsin and Michigan. A state conservation plan is being developed in Minnesota; once approved by both the State of Minnesota and the U.S. Fish and Wildlife Service, it will allow federal delisting in Minnesota.

In Ontario there is no evidence to suggest that wolves are threatened or endangered on either a regional or provincial basis. Observations by field staff and trappers suggest that wolf numbers are stable or increasing over nearly all of their historic range in the Province. The gray wolf population in Ontario is estimated at 8,000 to 9,000 animals (Buss and de Almeida 1997). Within the Ontario portion of the basin, wolf hunting and trapping is permitted year-round; however, wolves are essentially protected during the months of June through August, because the provincial small game-hunting license is not valid during this period. Hunting is prohibited in provincial and national parks, and trapping is prohibited, or minimal, in most provincial parks (Buss and de Almeida 1997). During the 1990s, the annual harvest of wolves has varied from 500 to 800 animals.

7.6.2.2 Unique Characteristics of Mammals

Many mammalian species, because they have been harvested for food and pelts, have seen dramatic changes in community structure and abundance. Also, because many mammals remain of interest to hunters and trappers, management programs focus on providing populations for harvest and not on the overall ecosystem. As a result, our society views these species primarily for their value to humans, not for their value as a functioning part of the ecosystem (see Addendum 7-B). Another consequence of single-species management is that impacts to the ecosystem, both positive and negative, were not historically considered. Single-species management is gradually being replaced with ecosystem management.

7.6.2.3 Stressors of Mammals

Overabundant Populations

The recovery of some species from near extirpation to overabundance has resulted in stresses to other species (see Addendum 7-A and 7-B). The management of overabundant deer, however, also provides opportunities to focus on ecosystem management principles and to manage wildlife communities as a whole.

Habitat

Habitat changes on the landscape have been a factor in the composition of mammalian communities (see Table 7-3). Habitat changes created by certain species, especially white-tailed deer, alter the composition of all mammalian communities.

Beaver also have a significant impact on the surrounding environment, especially riparian vegetation and adjacent aquatic communities. The long term management of beaver populations can be addressed through management of their riparian food source. The dominant aspen/alder riparian community we see today can be steered toward less palatable coniferous stands. The restoration of coniferous old-growth riparian forest will benefit both terrestrial and aquatic ecosystems.

Some species of particular concern have specific habitat requirements that must be met for their survival. For example, American marten and fisher require blocks of mature forest, and marten seem to prefer forests with a coniferous component. These requirements are an important consideration in timber management (Racey and Hessey 1989b). Standing hollow trees must be present for den sites for both species, and coarse woody debris is critical for winter rest sites for marten (Gilbert and others 1997).

Contaminants

Mammals that are top predators accumulate toxic chemicals in their bodies. These chemicals might be affecting their individual health and reproductive capability. Most contaminant monitoring in the Lake Superior basin, however, has focused on birds and fish.

Concern has been expressed about cadmium levels in liver and kidney tissue of deer and moose that exceed recommended daily intake levels for humans. While negligible amounts of cadmium have been found in Ontario deer and moose muscle (Glooschenko and Burgess 1987), the OMNR recommends that people do not eat the liver and kidneys of moose and deer because of the concerns about cadmium levels in these internal organs. Kronberg and Glooschenko (1994) suggested that cadmium could serve as a proxy for other heavy metals of concern, such as lead and mercury, and that analyzing moose tissues on a regular basis could be useful for monitoring changes in environmental levels of these elements.

Studies begun on fisher (Gerstenberger and others 1996) found elevated levels of chlordane, but much work remains to be done. Mink and otter are good indicators of contaminant effects on mammals in the Great Lakes; they are carnivores, consume significant amounts of fish, and have been found to be very sensitive to PCBs and mercury (Ensor and others 1993). PCBs negatively affect mink reproduction (Heaton and others 1992; Kubiak and Best 1991). A study to develop baseline contaminant data in wildlife in Minnesota (Ensor and others 1993) found elevated levels of PCBs in mink collected along Lake Superior, and three of the highest levels of mercury were from mink collected along Lake Superior. They suspect that high mercury levels in combination with PCBs may be impacting mink populations.

Public Demands

Many mammalian species were historically stressed by overharvest, but many populations have recovered with the implementation of hunting laws and regulations. Recent demands from the public have resulted in agencies also managing wildlife populations for non-consumptive uses. Conflicts can arise with how an agency manages certain wildlife species or communities.

7.6.2.4 Management Efforts for Mammals

Management and recovery of mammalian populations is done by the state, provincial, tribal, or federal agency that has authority.

7.6.2.5 Current Monitoring Efforts for Mammals

Management agencies usually monitor mammal populations, either through population indexes or harvest surveys.

Ontario initiated a Wildlife Assessment Program to monitor representative wildlife species that may be affected by forestry activities. Eighty-two species were selected as a measure of sustainable forest management; 23 of these species are mammals.
National forests in the United States are monitoring some mammalian species, especially those that are indicators of the impacts of forest management activities.
A few programs are monitoring contaminant levels in top predators.

7.6.2.6 Gaps in Mammal Information

None of the monitoring information on any mammal species has been compiled for the Lake Superior basin.

Very little research is being conducted on contaminants in mammalian predators in the Lake Superior basin.

A significant amount of research needs to be conducted on the long-term effects of herbivory on plants and animals. We need to better understand whether population management programs can reverse some of the negative trends that are seen. This type of monitoring and research should be done in conjunction with adaptive management strategies.

7.6.2.7 Challenges for Mammals

One of the biggest challenges concerning management of mammals is understanding what mammalian community structure represents a “healthy, sustainable terrestrial wildlife community.” As noted above, the current community profile of ungulates has changed drastically from what it was pre-European settlement. Do current conditions represent a healthy terrestrial wildlife community, or is the current community simply the one that will be most accepted by human society? Mammalian communities can have a substantial effect on habitat structure, which in turn affects other terrestrial wildlife and ecosystem functions.

The Binational Program is not, and should not be, in the position of defining a healthy, sustainable mammalian community at the population level. It can, however, help define healthy ecosystems in terms of habitat structure, landscape patterns, and disturbance regimes. The appropriate agencies, however, need to become more actively engaged on a landscape scale to address overlapping goals and objectives. If this is done, the Binational Program can advance those programs where goals overlap.

7.6.3 Birds

Birds receive substantial attention from many groups, including scientists, wildlife enthusiasts, anglers, and commercial fishermen. Birds constitute the greatest number of vertebrate species (~70) found in the Lake States national forests (Benyus and others 1992). Breeding songbirds are readily counted because they are both visually and aurally conspicuous. Their composition and abundance provide an indication of ecosystem health, and changes in their diversity and numbers can provide an early warning system for biologists trying to understand the status of the ecosystem. They are enthusiastically watched at feeders, migration points, parks, and in the wild by novice and expert birdwatchers. Commercial fishermen keep an eye on fish-eating birds, fearing direct competition. Birds that are carnivores, such as bald eagles and herring gulls, give us a direct indication of the amount of contaminants in the system, by the thickness of their eggshells and the health of their young.

For all these reasons, there is a substantial amount of information on birds in the Lake Superior basin. But like most terrestrial wildlife information, very little is compiled on a basinwide basis. Highlights of much of the available information are provided below.

7.6.3.1 Status and Trends of Birds

Songbirds

Trends in songbird populations can be measured on the basis of individual species, communities, habitat guilds, or migratory status. Populations can be reviewed nationally, regionally, or locally, depending on the data set that is available. The North American Breeding Bird Survey allows us to look at continent-wide trends, as well as regional trends. Local trends are available only if individual studies or monitoring programs have been established. The Lake Superior basin has abundant information at all levels, but it has not been compiled on a basinwide basis. Therefore, we can only provide some relative trend information that is currently compiled at the national and regional level.

Portions of the Lake Superior basin have some of the highest species richness for breeding birds in North America, especially the southern and northwestern shores (Sauer and others 1997; Green 1995). Certain forest species appear to be more abundant, widespread, or productive in northern Wisconsin than in other regions. For these species, the Lake Superior basin could provide source populations. Some species include American woodcock, broad-winged hawk, black-billed cuckoo, winter wren, veery, blackburnian warbler, black-throated green warbler, and scarlet tanager (Howe and others 1992). The Minnesota portion of the basin also has some of the highest woodland species richness in North America (Sauer and others 1997).

Recent concerns have been raised about the decline of neotropical migrant bird populations (those birds that breed in North America and winter in Central or South America). Some neotropical migrants that are characteristic of Lake Superior forests have shown significant declines on a continent-wide basis, including eastern wood-pewee, wood thrush, veery, and indigo bunting (Peterjohn and Sauer 1994). The decline can be attributed to several factors, including habitat loss on their wintering range, changes in forest habitat in their breeding range, and migration obstacles. Concurrently, several species of neotropical migrants have shown an increase since 1966 on a continent-wide basis, including red-eyed vireo, solitary vireo, ovenbird, and pine warbler (Peterjohn and Sauer 1994). Many of the songbirds in the basin are neotropical migrants. For example, in Minnesota Green (1995) reported that 43 percent of the forest birds are neotropical migrants. Use of the basin by neotropical migrants is important for two reasons: 1) if the ecosystem is healthy, the basin should be an area where these migrants can produce young and serve as source populations, and 2) factors outside the basin can have a significant effect on songbird populations.

Local surveys, especially those that are done in forest interior, show finer trends in woodland birds. For example, the Ontario Forest Bird Monitoring Program indicates that based on analysis of 69 species, 35 showed an increasing trend (11 significant) and 34 showed a decreasing trend (9 significant). In the Boreal Ecozone, significant declines were seen for brown creeper, golden-crowned kinglet, eastern wood-pewee, winter wren, and ovenbird. Significant increases were seen for yellow-bellied sapsucker, great-crested flycatcher, white-breasted nuthatch, northern waterthrush, red-eyed vireo, pine warbler, and chipping sparrow (Cadman and others 1998).

A regional analysis of BBS data was conducted for northeastern Minnesota, specifically the Great Lakes transition forest and the spruce hardwood forest regions (Niemi and others 1995). They compared data in these regions of Minnesota with statewide trends. Table 7-4 summarizes their findings.

Table 7-4 Summary of Breeding Bird Survey Analysis in Northeastern Minnesota, 1966-1993

Species that showed a decline statewide, as well as in both regions:	**Species that showed a decline statewide, but not in the two regions:**	**Species that showed a decline in the two regions, but not statewide:**
American Bittern	American Redstart	Blue-winged Teal
Ruffed Grouse	Red-headed Woodpecker	Brown Thrasher
Belted Kingfisher		Field Sparrow
Northern Flicker		Vesper Sparrow
Eastern Wood-pewee		Eastern Meadowlark
Least Flycatcher		
Ruby-crowned Kinglet		
Grasshopper Sparrow		
Western Meadowlark		
Brown-headed Cowbird		
Species that showed an increase in the state and in both regions:		**Species that showed an increase in the two regions, but not statewide:**
Common Loon	Red-breasted Nuthatch	Black-billed Cuckoo
Pied-billed Grebe	White-breasted Nuthatch	House Wren
Canada Goose	Sedge Wren	Marsh Wren
Wood Duck	Eastern Bluebird	Warbling Vireo
Mallard	Swainson's Thrush	
Red-tailed Hawk	Yellow-throated Vireo	
Common Snipe	Yellow-rumped Warbler	
Downy Woodpecker	Black-throated Green Warbler	
Hairy Woodpecker	Scarlet Tanager	
Pileated Woodpecker	Swamp Sparrow	
Eastern Phoebe	Northern Oriole	
Blue Jay	Evening Grosbeak	
Common Raven		
Black-capped Chickadee		

Source: Niemi and others 1995

Trends from this analysis indicate:

- Some bird species of mature forests are increasing (e.g. downy woodpecker, Swainson's thrush, pine warbler) and some are decreasing (e.g. least flycatcher, eastern wood-pewee).
- Species associated with fragmented forest landscapes are increasing (e.g. American kestrel, yellow-throated vireo, warbling vireo).
- Species associated with human habitation and human-dominated landscapes are increasing (Canada goose, wood duck, blue jay, black-capped chickadee, house wren, eastern bluebird). Some of these increases are a direct result of recovery programs for specific species, such as wood ducks.
- Four of the species that are increasing are highly associated with lakes and ponds (common loon, pied-billed grebe, double-crested cormorant, and great egret). These are fish- and aquatic-feeding species that were likely affected by chlorinated organic compounds in the 1950s and 1960s. Their increases parallel those of bald eagle and osprey.
- Several species of agricultural, rural landscapes have decreased (e.g. upland sandpiper, red-headed woodpecker, northern flicker, field sparrow, vesper sparrow, meadowlark). Possible reasons for decline include reduction and fragmentation of native grasslands, reductions in hayfields and pastures, and changes in agricultural practices.
- Several species associated with shrub/sedge wetlands are increasing (e.g. common snipe, sedge wren, LeConte's sparrow, and swamp sparrow). Wetlands in northern Minnesota remain in a relatively natural state when compared to other parts of Minnesota.[1]

Raptors

Bald Eagles

Populations of bald eagles declined sharply in the 1950s and 1960s as a result of contamination by toxic chemicals that accumulated in the food chain and affected reproductive success of eagles and other carnivores. Along the Lake Superior shoreline, bald eagles were nearly absent through the 1970s, but the population began to increase as the use of DDT was halted and DDE concentrations began to decrease. (DDE is a byproduct of DDT. It inhibits the action of the enzyme that is needed to transfer calcium carbonate to the eggshell.) Trend information for the three states and Ontario is provided in the habitat section of this LaMP.

Reproductive success of eagles that nest along the Lake Superior shoreline, and especially on islands, is lower than inland. This may be due to reduced availability of prey on Lake Superior and inclement weather. In Wisconsin, populations are increasing inland, but remain stable on the lake (Dykstra and others1998). Michael Hoff, (U.S. Geological Survey, personal communication) suggests that burbot population dynamics play an important role in food availability, as well as the role of commercial fishermen in casting off unused catch.

Migratory Raptors

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1) It is important to note, however, that coastal wetlands are threatened and of concern in the entire Great Lakes region.

Migrating raptors seek thermals to make their flights more efficient. Because thermals rarely form over water, raptors prefer to migrate around Lake Superior. Several locations around the lake provide other physiographic features (such as ridges) that concentrate raptors during migration. These locations provide excellent sites for monitoring raptors and other birds during migration (Ryan Brady, Northern Great Lakes Visitor Center, Ashland, WI, personal communication). Hawk Ridge in Duluth, Minnesota, and Whitefish Point, Michigan, are two well-known hawk migration viewing areas on Lake Superior.

Colonial Waterbirds

Colonial waterbirds are good bioindicators of contaminant levels. Herring gulls and other long-lived fish-eating birds show the effects of prolonged exposure to toxic chemicals and help us understand wildlife health. Herring gull monitoring has occurred for more than 25 years in the Great Lakes. Two annual monitoring sites are located in Lake Superior (Mineau and others 1984; Pekarik and Weseloh 1988; Hebert and others1999).

Most colonial waterbirds had nearly disappeared in the early 1900s before the Migratory Bird Convention of 1916 provided some protection. Birds like herring gulls were valued for their feathers and were persecuted at nest sites. After they were protected through federal laws, their numbers began to increase in the 1940s. But by the early 1970s, herring gull populations had once again decreased. Contaminants were blamed, especially persistent chemicals such as DDE, PCBs, and dioxin, which affected eggshell thickness and embryonic growth and caused other problems (Gilbertson 1974; Mineau and others 1984). The mid-1970s saw the greatest concentrations of these toxic chemicals in herring gull eggs, but the levels have decreased since then (Bishop and others 1992a, 1992b; Pettit and others 1994a, 1994b; Pekarik and others 1988a, 1988b). Herring gull populations are recovering in the Great Lakes, but numbers in Lake Superior have shown declines (Table 7-5). Declines could be due to a smaller food base in Lake Superior (Weseloh and others 1999). Also, contaminants remain in the Lake Superior ecosystem and can continue to cause problems in certain areas (Ryckman and others 1997).

Table 7-5 Number of Herring Gull Nests (pairs) on Lake Superior in 1976-77, 1989-90, 1998 and 1999

	1976-78		1989-90		1999	
	pairs	colonies	pairs	colonies	pairs	colonies
Canada	6,410	149	12,181	299	1,115*	301*
% change from last survey			90.0%	100.7%	<-8.7%	<1.0 %
U.S.	7,106	90	13,263	187	7,715	134
% change from last survey			86.6%	107.8%	-41.8%	-28.3%

** Preliminary data, some sites missing; Compiled from: McKearnan, personal communication; C. Pekarik and C. Weseloh, personal communication; Cuthbert and McKearnan 1999.*

Double-crested cormorants have also seen unnatural fluctuations in their populations. It is believed that cormorants did not historically breed in Lake Superior and the Great Lakes. The first suspected nesting occurred on the western end of Lake Superior in 1913 (Weseloh and Collier 1995). This was likely an eastward expansion of the Lake of the Woods population.

There was a continual expansion of cormorants into the Great Lakes, and by the late 1940s and 1950s the cormorant had become so common that control measures began, especially on the lower Great Lakes. People suspected that cormorants competed with commercial and sport fisheries. There were both sanctioned and unsanctioned control measures, including annual destruction of colonies by shooting adults and destroying eggs and young. Control measures largely ended by 1960.

Cormorant populations declined drastically throughout the 1960s and early 1970s. By 1973, breeding cormorants had completely disappeared from Lake Superior (Weseloh and Collier 1995). One of the leading reasons for the decline—if not the leading reason—was contamination by toxic chemicals. Cormorants, like many fish-eating birds, were producing thin eggshells because they had accumulated DDE in their system. They were breaking their eggs by lying on them. Deformities were also noted, probably caused by agents such as PCBs (Weseloh and others 1995).

In the mid-1970s, with decreased use of toxic chemicals, cormorants began a dramatic recovery. They increased by 300-fold between 1971 and 1995 in the entire Great Lakes region. Lake Superior saw a slower growth (Figure 7-4), mostly because it is less productive than the lower lakes, so it has a reduced food base. The rate of bill deformities also decreased (Weseloh and Collier 1995; Ryckman and others 1998).

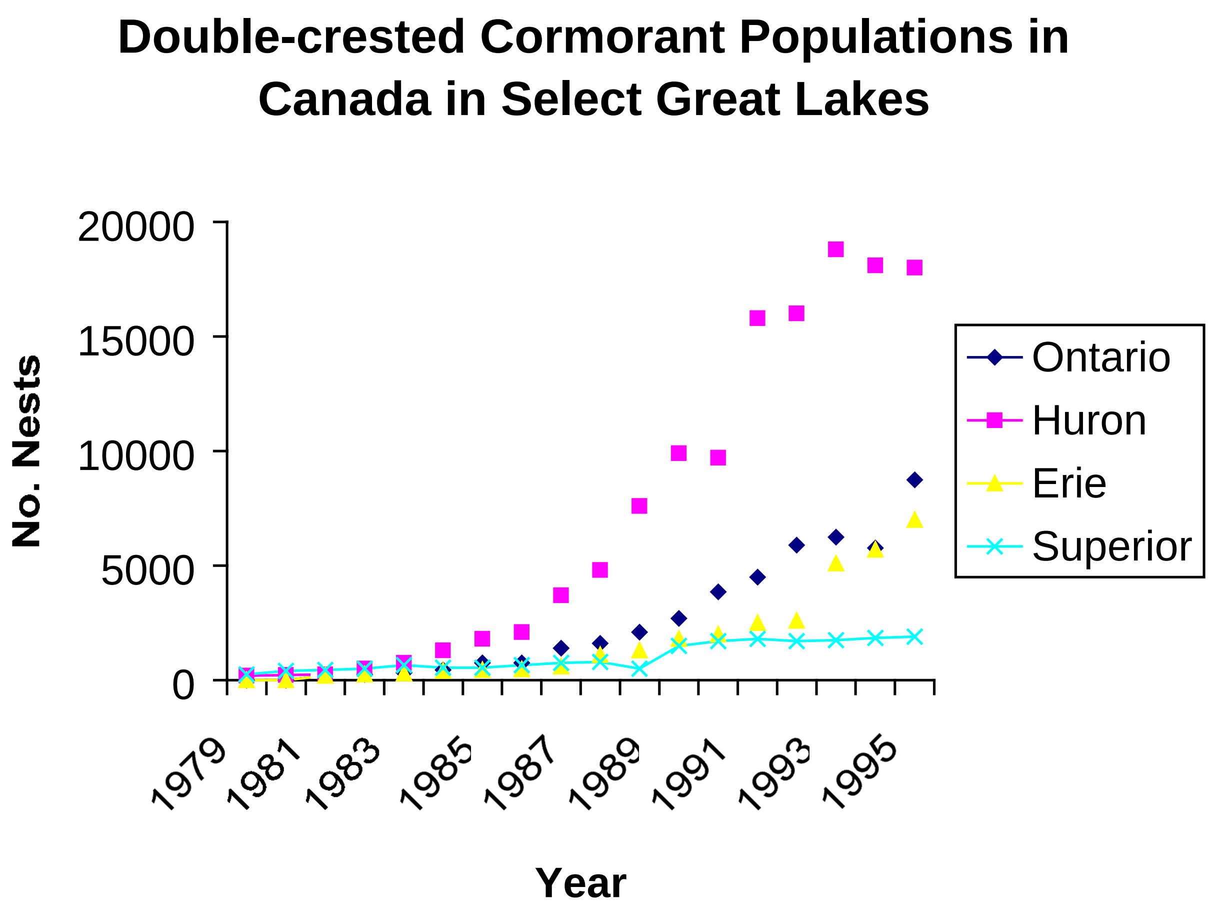

Figure 7-4. Double-Crested Cormorant Populations

Source: Weseloh and others 1999.

The American white pelican, generally considered a bird of the great plains/prairie regions of North America, has become established in the Lake Superior basin. Breeding colonies were discovered in the early 1990s on Lake Nipigon. These birds are believed to have come from breeding colonies on Lake of the Woods, which is located along the Manitoba/Ontario/Minnesota border (Bryan 1994 and Escott 1991).

Other Waterbirds

Shorebirds

Some information is available on the status of shorebirds east of the Rocky Mountains (Harrington 1995). Most information was gathered from migratory bird surveys and some from breeding bird surveys. Population trends were evaluated for 27 of 41 shorebird species. Of these, 12 showed no change, 1 increased, and 14 decreased. Some species that are of interest to the basin are: spotted sandpiper - no change; common snipe - significant decline; piping plover - endangered; American woodcock - significant decline.

Migration habitat is critical for many shorebirds. A high proportion of them migrate by visiting one or a small number of “staging sites,” areas where the birds can accumulate fat. These staging sites are often productive areas with highly predictable but seasonally ephemeral “blooms” of invertebrates. The St. Louis River estuary at the Duluth-Superior Harbor is used by many species of shorebirds and could be a significant staging site for Lake Superior (Pat Collins, MN DNR, Two Harbors, personal communication). We are not aware of other heavily used sites on Lake Superior.

Common Loons

Most common loon pairs use inland lakes in the basin for breeding sites. Lake Superior is used by loons as a staging area, including Whitefish Point in Michigan. Isle Royale has a large loon population for its size, and some of these loons nest on Lake Superior (Michigan Loon Recovery Program 1992).

Loon reproductive success in Ontario decreased between 1981 and 1997. Loons breeding on acid lakes declined more rapidly than those on more alkaline lakes (Weeber 1999). In the upper Great Lakes, loons nesting on acid lakes were more susceptible to mercury contamination (Evers and others 1998).

Minnesota has the largest summer population of loons in the lower 48 states, and northeastern Minnesota is an important area (Strong and Baker 1991). Michigan had only about 300 pairs in 1988, and about 165 of these were in the Upper Peninsula (Michigan Loon Recovery Program 1992). Wisconsin saw an increase in its loon population from 1985 to 1995, probably due to good reproduction from 1986-1990, which was mostly weather-related (Daulton and others 1997).

Waterfowl

Lake Superior and the basin is not a hot spot for waterfowl production. The lake provides important habitat for migratory waterfowl, especially diving ducks. Coastal wetlands also provide important habitat for both breeding and migrating birds.

Information has not been compiled for the Lake Superior basin. Most waterfowl indices for North America are created from surveys done outside the basin. However, we can look at trend data for Minnesota, Wisconsin, and Michigan (Figure 7-5). Overall, waterfowl numbers are increasing, except for a few select species, such as the American black duck. The increase in numbers in North America is mostly due to ideal conditions in the prairie region and Alaska. Increase in abundance is also reflected in the data from Minnesota (U.S. Fish and Wildlife Service 1998). We don’t know whether Lake Superior has contributed to waterfowl populations overall.

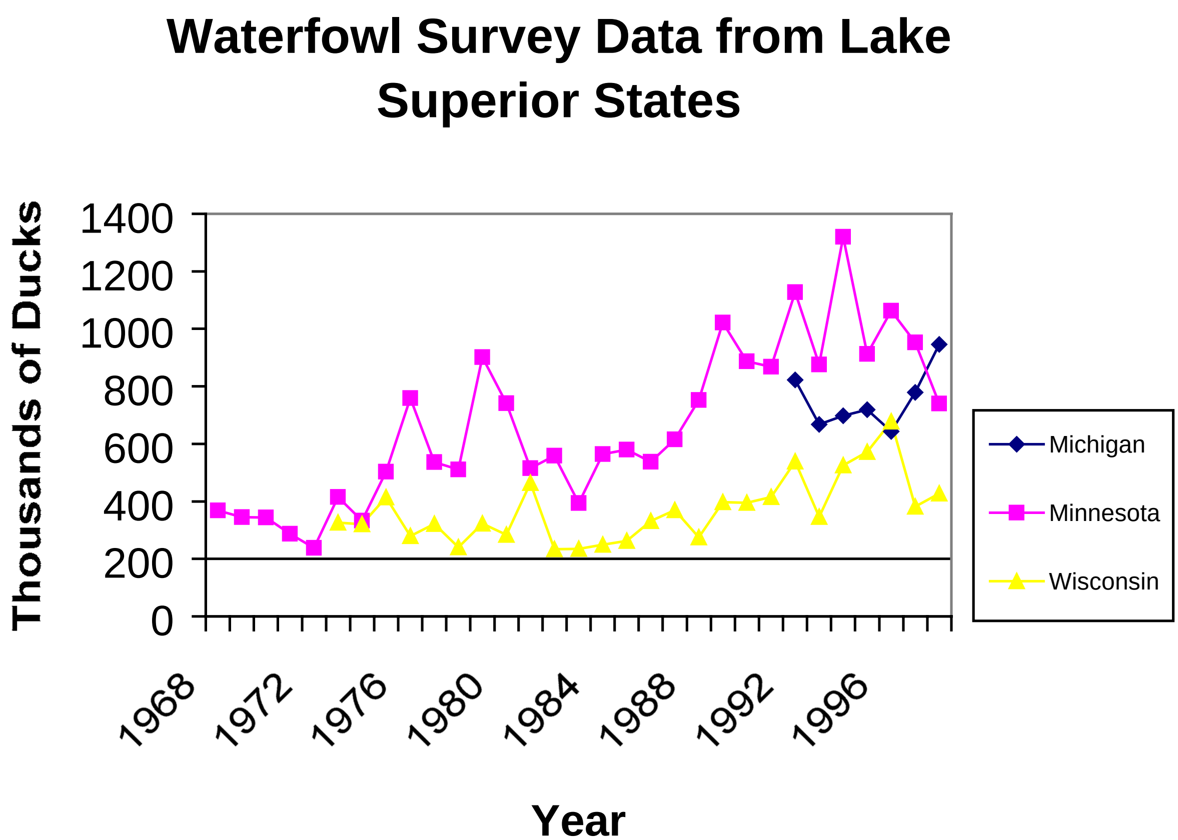

Figure 7-5. Waterfowl Survey Data
Source: U.S. Fish and Wildlife Service 1998.

Federally Threatened and Endangered Species

(Detailed information about these species is provided in the habitat chapter (Chapter 6) of the LaMP.)

Piping Plovers

The Great Lakes population of piping plovers remains precarious. The birds nest on sandy shorelines, which are often subject to human use. A recovery plan specifically for the Great Lakes is in draft form.

Bald Eagles

This species is soon to be delisted as a federally threatened species in the United States, but productivity of Lake Superior pairs remains uncertain. It is still listed as endangered in Ontario.

Kirtland's Warbler

The main population of Kirtland's warbler is found outside of the Lake Superior basin, but the population is expanding, and a few singing males have been counted in the Upper Peninsula of Michigan. It is possible that recovery efforts could involve habitat in the Lake Superior basin.

Peregrine Falcon

Successful recovery efforts allowed the peregrine falcon to be delisted in the United States in 1999. It was recently downlisted from endangered to threatened in 1999 in Canada; its status remains uncertain in the southern part of its range.

7.6.3.2 Unique Characteristics of Bird Habitat

Lake Superior is dotted with islands that provide important habitat for migratory birds, including colonial waterbirds, songbirds, and raptors (Blokpoel and Scharf 1999; Vigmostad 1999). Special considerations for these habitats include the fact that many of them are managed as national parks or protected in some way. They also provide an environment that is different from mainland habitat. They require special consideration in research, management, and protection.

7.6.3.3 Stressors of Birds

Chemical Contaminants

The presence of elevated levels of toxic chemicals coincides with poor health, reproductive impairments, and other physiological problems in herring gulls, as well as ring-billed gulls, double-crested cormorants, black-crowned night-herons, bald eagles, common terns, Caspian terns, and Forster's terns. This is related to reduced hatching success, eggshell thinning, abnormal adult behavior, deformed embryos, and hatched young, biochemical changes, endocrine disruption, and suppressed immune function (Fox and others 1998).

Currently, contaminants are being released or recycled by atmospheric deposition, agricultural land run-off, slow leaching of discarded stocks of pesticides and other chemicals from landfill sites and agricultural soils into the Great Lakes via groundwater and resuspension of contaminated lake/river sediments. On Lake Superior, up to 90 percent of toxic contaminants entering the lake comes from the atmosphere in the form of precipitation (Eisenreich and others 1981). Table 7-6 summarizes contaminant-related effects in fish-eating waterbirds.

Table 7-6 Summary of Some Contaminant-related Effects Observed in Herring Gulls and Other Fish-eating Waterbirds Inhabiting the Great Lakes.

Contaminant Effect	**Evidence in the Great Lakes**	**Current Status**
Eggshell Thinning - caused by high DDE levels in the 1950s, 1960s, and 1970s.	Resulted in widespread eggshell breakage, causing population declines of fish-eating waterbird species including double-crested cormorants, ospreys, bald eagles, black-crowned night-herons, and herring gulls.	Due to regulatory controls and banning of DDT, eggshell thinning is no longer a problem, resulting in improved reproductive success of affected species.
Reproductive Failure -causes include early embryonic death, embryo toxicity, and abnormal parental behavior during incubation.	Herring gulls, double-crested cormorants, and bald eagles were not reproducing during the late 1960s and 1970s when highest levels of organochlorines were present.	Due to significant declines in organochlorine levels, reproductive success has improved in most fish-eating waterbird species.
Biochemical Changes	Abnormal liver functions and low levels of Vitamin A may increase susceptibility to infectious diseases, possibly affecting the survival and development of young chicks.	Biochemical measures indicate that herring gulls are still chemically stressed. Full effect of biochemical changes on the reproduction or life span of waterbirds is not known at this time.
Suppressed Immune Function -several contaminants (e.g. PCBs and TCDDs) suppress important immune functions and can increase susceptibility to infectious diseases.	At highly contaminated sites, herring gulls and Caspian terns have suppressed T-lymphocyte function, atrophy of the thymus gland, and altered white blood cell counts.	Research is underway to determine the extent and significance of suppressed immune function in fish-eating waterbirds.
Congenital Deformities	Crossed bills, jaw defects, extra limbs, and malformed feet, joints, and eyes were found in herring gulls and at least eight other species of fish-eating waterbirds.	Waterbirds continue to display higher rates of deformities compared to clean sites outside of the basin. Studies continue on the links between contaminants and developmental problems in certain waterbird species.

Source: Ryckman and others 1997

Habitat

Habitat changes and landscape patterns have very strong effects on birds, especially migratory songbirds. Because the Lake Superior basin is primarily forested, the composition, size, and structure of forests strongly affects songbird species diversity, abundance, and productivity. For example, some songbirds prefer to nest in forest interiors (ovenbird), and others prefer disturbed, open habitats (indigo bunting). Some require dead, standing trees (pileated woodpecker), and some prefer dense shrubs under a canopy (black-throated blue warbler). Others prefer a mix of hardwood and conifer forests (black-throated green warbler). Therefore, habitat changes and forest management policies affect each species differently. However, the following habitat changes are known to be negative for forest birds in general and have caused stresses to populations:

- Even-aged stands of hardwoods with little understory decrease bird species diversity (Howe and Mossman 1995, Green 1995).
- Some bird species are dependent on conifers (Green 1995) or prefer conifers (Howe and Mossman 1995), and loss of conifers affects abundance of those species.
- Neotropical migrant birds often increase in diversity and abundance as woodland size in fragmented landscapes increases (Friesen and others 1995).
- Shape of woodlands also plays an important role. A woodland with minimal edge is likely to have greater bird production than one with maximum edge. Edge creates many problems, including increased predation, intrusion of invasive species, and human disturbance. Edges have the effect of increasing temperature and wind, and lowering humidity in the forest interior.
- Neotropical migrant birds consistently decrease in diversity and abundance as adjacent home development increases, regardless of forest size. This study was conducted in a heavy agriculture landscape in southwest Ontario with about 14 percent of the landscape wooded (Friesen and others 1995).
- Hard edges have a detrimental effect on most species of concern, even disturbance-dependent species such as indigo bunting (Suarez and others 1997). Soft edges and residual habitat in clearcuts are preferred (Merrill and others 1998, Suarez and others 1997).
- Large gaps without cover between woodlands are detrimental to some forest birds. The creation or preservation of woodland corridors for these species is important (Desrochers and Hannon 1997).

Even non-native plant species negatively affect bird productivity. For example, buckthorn, which replaces native hawthorn, lacks sharp thorns that might deter predators. A study showed that productivity of robins and wood thrushes decreased for birds nesting in non-native shrubs (Schmidt and Whelan 1999).

Habitat changes created by shoreline development affect many species of birds and create dramatic changes in avian community guilds. A study by Gillum and others (1998) showed that ground-nesting birds decrease in numbers as development increases, probably due to vegetation alteration, increased predation, and nest disturbance. Insectivorous species are less common along developed shoreline. The proportion of omnivores, nectivores, frugivores, or seed eaters is two times greater at developed lakes than at undeveloped lakes. Concerns are mostly related to species that are considered source/core species of northern Wisconsin, such as ovenbird, hermit thrush, black-and-white warbler, black-throated green warbler, and brown creeper, because they are displaced by development. Intensive shoreline development also eliminates habitat for certain water-dependent species such as herons and kingfishers (Gillum and others 1998).

Human Disturbance

Species such as loons can be negatively affected by direct human disturbance. Unsuspecting recreational users sometimes chase birds off their nest, leaving eggs or chicks susceptible to heat or cold. Loons also become entangled in commercial trap nets, fishing lines and hooks, and ingest lead fishing sinkers (Michigan Loon Recovery Program 1992).

Songbirds that nest on or near the ground are susceptible to predation by domestic cats and dogs.

Invasive and Nuisance Species

Cowbirds

Brown-headed cowbirds parasitize the nests of songbirds, laying their eggs in the nests of other species. The adult songbirds raise and feed the cowbirds to maturity, reducing their own nesting productivity. Cowbirds thrive in edge habitat, especially if the edge habitat is near to mowed grass or pasture, which is where they feed. In the Lake Superior basin, cowbirds are a problem where human habitation is the greatest and in agricultural landscapes, but they are not a major concern in the basin overall.

Non-Native Plants

Non-native plants can have a negative effect on habitat structure, resulting in decreased biodiversity. Schmidt and Whelan (1999) showed the effect of non-native shrubs on robin and wood thrush productivity. Predation of both species was higher in non-native shrubs than in native shrubs and trees, likely due to structural differences in non-native plants that provided easier access for predators.

7.6.3.4 Management Efforts for Birds

In general, states, tribes, and the Province of Ontario have regulatory authority and management responsibility for resident wildlife, which includes resident birds. Federal governments have regulatory authority and management responsibility for migratory birds. Federal agencies that manage federal lands have management responsibility for both resident and migratory birds. However, many responsibilities for migratory birds are shared between states and the federal government. Some examples are:

North American Waterfowl Management Plan - Recognizing the importance of waterfowl and wetlands to North Americans and the need for international cooperation to help in the recovery of a shared resource, the Canadian and United States governments developed a strategy to restore waterfowl populations to 1970s levels through habitat protection, restoration, and enhancement. The strategy was documented in the North American Waterfowl Management Plan signed in 1986 by the Canadian Minister of the Environment and the United States Secretary of the Interior, the foundation partnership upon which hundreds of others are built. In 1994, the Mexico Secretario de Desarrollo Social signed the Plan, expanding the efforts to protect wetlands and improve waterfowl populations. The Lake Superior basin is included in the Great Lakes/Upper Mississippi Joint Venture.

U.S. Shorebird Conservation Plan - The U.S. Shorebird Conservation Plan is a collaborative effort among researchers, land managers, and education specialists from the United States who cooperate with colleagues from Canada and Mexico to advance effective conservation of North American shorebird species. The plan was initiated in 1997.

North American Colonial Waterbird Conservation Plan - This effort was initiated in 1998. The mission is to create a cohesive, multinational partnership for conserving and managing colonially-nesting waterbirds (seabirds, wading birds, terns, gulls) and their habitats throughout North America. A plan will be implemented to maintain healthy populations, distributions, and habitats of colonial-nesting waterbirds in North America, throughout their breeding, migratory, and wintering ranges.

North American Bird Conservation Initiative - NABCI was initiated in 1999 by representatives of federal, state, and provincial agencies, as well as nongovernmental organizations, to create a framework that would foster coordination among bird initiatives with the aim of conserving all of North America’s bird resources.

Circle of Flight - This program provides funding and technical assistance to lake state tribes for wetlands protection, restoration, enhancement, and management projects. Many tribes have reseeded and now manage wild rice beds under this program. Thousands of acres of wetlands have been restored or enhanced since the program’s inception in 1991. The program is administered by the U.S. Bureau of Indian Affairs and U.S. tribes. It involves many partners.

7.6.3.5 Current Monitoring Efforts for Birds

Songbirds

North American Breeding Bird Survey - Established in 1966, this program is a joint effort of Canada and the United States. Volunteers and natural resource agency employees complete selected roadside counts once a year. This program provides long-term trend data over a broad geographic area. The information is not currently compiled or analyzed for the basin.
Ontario Forest Bird Monitoring Program - This program began in 1987. Its goals are to: 1) compile a habitat-specific baseline inventory of forest songbirds, 2) describe changes over time in the numbers of forest songbirds in relation to habitat and landscape characteristics, and 3) contribute to an understanding of population trends for forest birds in Ontario. This information supplements breeding bird survey data (Cadman and others 1998).

Ontario Landbird Monitoring Strategy - This program encompasses all landbird monitoring, including breeding and migration monitoring. It is part of the Canadian Landbird Monitoring Strategy.

Marsh Monitoring Program - The Marsh Monitoring Program began in 1994 in order to monitor the condition of marshes in the Great Lakes basin, using marsh birds and amphibians as indicator species. Volunteers survey marsh birds, amphibians, or both. The Marsh Monitoring Program is a cooperative venture of Environment Canada and Bird Studies Canada. Migration monitoring is done at Thunder Cape, Ontario; Whitefish Point, Michigan; and Hawk Ridge, Duluth, Minnesota.

Songbird monitoring is conducted on many public lands to measure the effect of management on avian populations. Lands that are monitored in the basin include: U.S. national forests (Chequamegon Nicolet, Superior, Ottawa), U.S. national parks (Apostle Islands and Isle Royale), tribal lands (Red Cliff and Bad River), and national wildlife refuges (Whittlesey Creek).

Colonial Waterbirds

Herring gulls are monitored for contaminants, populations, and productivity. The herring gull is considered one of the major indicator species for environmental contamination in the Great Lakes. This program has been in place for more than 25 years and is one of the longest running wildlife monitoring programs for contaminants in the world. Two of the 15 monitoring sites are on Lake Superior: at Granite Island, east of Thunder Bay, and at Agawa Rocks, south of Wawa. Populations of cormorants, gulls, terns, and herons are monitored in the entire Great Lakes on both the Canadian and United States sides at varying intervals.

Waterfowl

Breeding pair and brood surveys are conducted in Minnesota, Michigan, Wisconsin, and Ontario, but a large area of the basin is not included in these surveys.

Loons

State and provincial agencies along with various loon watch programs monitor breeding pairs and productivity.

Work was recently initiated by the BioDiversity Research Institute to monitor contaminants in loons.

Bald Eagles

Nesting pairs are monitored along the Great Lakes and inland lakes in the basin by the states and Ontario. Productivity is monitored in select areas.

Habitat

Habitat changes at the landscape level are being monitored using computerized geographic information system (GIS) software. Satellite photographs, starting from the late 1980s, have been interpreted (at 200 x 200 meter resolution) and entered into GIS data layers

7.6.3.6 Gaps in Bird Information

Little information has been compiled specifically for the Lake Superior basin, but there is a lot of information available, especially for breeding birds, loons, bald eagles, and colonial waterbirds. Once the information is compiled for the basin, an analysis should be conducted to determine where the information gaps are.

Monitoring was initiated on contaminants in tree swallows, but work has slowed due to lack of funds.

The ongoing GIS data could be developed at a finer resolution (50 x 50 m) and interpreted every ten years to allow comparison over time. Linkages need to be made with landscape-scale habitat changes to songbird communities.

7.6.3.7 Challenges for Birds

Lake Superior forests provide very important habitat for migratory songbird populations, some of which probably serve as source populations for other areas. With concerns expressed nationwide over the decline of neotropical migrants, the Lake Superior basin should be considered a critical region for migratory songbird conservation. Significant work continues on population monitoring; some of this is being linked to habitat changes at the landscape scale. The Binational Program would be a logical organization to work toward compiling this information for the Lake Superior basin and providing it to project partners. The Binational Program should also provide recommendations for habitat conservation strategies to its project partners and to local units of government in the throes of land use planning.

Conservation of migratory songbirds remains uncertain because of the complex interactions between birds and their landscapes. However, Howe and others (1995) provide some recommendations that can be used to help guide conservation and management efforts. They include: 1) establish realistic conservation goals at several administrative levels, 2) select species that can be used as guidelines, 3) identify specific populations where priority species occur and implement appropriate management in these locations, 4) coordinate planning strategies among forest management units, and 5) design monitoring strategies to track populations and management actions.

Contaminant levels are being monitored in colonial waterbirds. This work needs to continue and should be coordinated closely with other contaminant studies being conducted in the basin. This is especially critical considering the goal of zero discharge for the Lake Superior basin.

7.6.4 Amphibians and Reptiles

7.6.4.1 Status and Trends of Amphibians and Reptiles

Little work has been done on amphibians and reptiles in comparison to other vertebrates. Until 10 to 15 years ago, few agencies and organizations even considered them in conservation efforts. Therefore, historical population data is mostly incidental. Species ranges are often derived from museum collections and records. Current efforts to monitor populations and to study the effects of anthropogenic influences have given us an increased awareness and concern for amphibian and reptile communities.

There are approximately 17 species of amphibians and 14 species of reptiles in the Lake Superior basin. Generally, the abundance and diversity of amphibians and reptiles is dependent on climatic conditions. The short growing season and cold, severe winters limit the number of species that can survive in the Lake Superior basin.

Species richness is more limited in the northern end of the basin. Eight reptile species may occur within the Ontario portion of the basin; however, at least half of these species have very limited ranges because they are at the extreme northern limit of their distribution. Fifteen amphibian species are found within the Ontario portion of the basin.

Populations of amphibians and reptiles are affected by many factors, and the overall trend for any species is not known. As with many vertebrates, the widespread changes in habitat cover across the landscape have had a dramatic effect on the community composition of amphibians and reptiles. For example, areas in the southern part of the basin that were historically mixed forest probably included species such as redback and blue-spotted salamander and species that are dependent on logs and downed branches, such as American toads, wood frogs, and redbelly snakes (Oldfield and Moriarty 1994). If those areas are logged and converted to agricultural lands, the amphibian species composition changes to those tolerant of human disturbance. Even then, the habitat must contain cover, a prey base, and water. Where these are present, American toads, garter snakes, and painted turtles might be present (Oldfield and Moriarty 1994).

Estimates of population trends for amphibian species in Wisconsin and Minnesota are available (Table 7-7). Local population declines of many amphibians are becoming a concern worldwide. Many possible reasons exist for these declines (see stressors section). Monitoring programs have been initiated to document trends.

Table 7-7 Status of Amphibian Species Found in the Lake Superior Basin in Minnesota and Wisconsin

Species	MN	WI
Wood frog	→	↑
Northern leopard frog	→↓	↓
Pickerel frog		↓
Mink frog	?	?
Green frog	→	→
Chorus frog	?	→
Northern spring peeper	→	↓↓
Eastern gray treefrog	→	→
Cope's gray treefrog	?	↓
Blanchard's cricket frog	SC	SE
American toad	→	→
Blue-spotted salamander	→	→
Eastern tiger salamander	↓?	
Spotted salamander		→
Four-toed salamander	?	SC
Redback salamander	→	
Mudpuppy	?	?

? – unknown, → - relatively stable, ↑ - increasing, ↓ - decreasing
SE - State Endangered, SC - Special Concern
Compiled from Casper 1998; Moriarty 1998; Mossman and others 1998

Some specific examples of species found in the basin and their estimated status are listed below.

Blue-Spotted Salamander

This is a relatively widespread species, which is tolerant of both cold temperatures and human habitat disturbance. They may be common in woodlands with the required breeding ponds. They are tolerant of selective logging and low-density residential development, as long as the critical parts of the habitat remain intact. Local populations are threatened by clear-cuts and roads that separate breeding ponds and terrestrial habitats (Harding 1997).

Northern Spring Peeper

Spring peepers are common in the Lake Superior basin. They require temporary and permanent ponds, marshes, or ditches for breeding. After breeding, they disperse to old fields, woodlands, and shrubby areas. They remain abundant, but their wetland habitats must be conserved to ensure they do not become a species of concern (Harding 1997).

Northern Leopard Frog

The leopard frog is probably one of the best known frogs, largely because it was often dissected in school biology labs. It is a widespread, ubiquitous species, but there have been significant declines in parts of its range, including Minnesota, Wisconsin, and Ontario (Mossman and others 1998; Casper 1998; Moriarty 1998; Seburn and Seburn 1997). Leopard frogs were completely absent from a large area of northern Ontario in 1997, indicating a major population decline there (Seburn and Seburn 1997). Collections by biological supply houses have been suggested as a potential problem, but there could be other reasons for the decline, such as disease, weather, and exposure to ultraviolet radiation (Seburn and Seburn 1997).

Snapping Turtle

The common snapping turtle is a large freshwater turtle that can live as long as 50 years. They are fairly common in the southern part of the basin, but they are at the edge of their range in Ontario. They are omnivorous, and because they eat a lot of animal matter, they may be exposed to higher concentrations of contamination than most other turtle species, which are mainly vegetarian. Their eggs, which are laid in sand next to water, are often eaten by skunks, foxes, and raccoons, and hatchlings are often eaten by avian predators. The adults are harvested for their meat. Snapping turtles are often thought of as common, but all the factors listed here make them vulnerable to population declines (Shirose and others 1996).

Wood Turtle

The wood turtle is found in the southern part of the basin and may occur in Ontario near Sault Ste. Marie. It is rare in the basin, and its numbers are thought to be declining. Like the snapping turtle, it is long-lived, but it does not reach maturity in northern latitudes until 14 to 18 years of age. A female lays one clutch of eggs, which are quickly taken by mammalian predators. It was collected by biological supply houses until recently, it is a target of people collecting turtles for the pet trade, and it is also harvested for food. Its home range can be very small (0.25 ha) to relatively large (100 ha) (K. Smith, personal communication), making it vulnerable to habitat loss and direct exploitation. (Harding 1997; Oldfield and Moriarty 1994).

It is important to understand how amphibians respond to changes in the ecosystem. Most amphibians are secretive, so it isn’t readily obvious that they constitute a large percentage of the biomass of terrestrial ecosystems. Because amphibians and reptiles are often in the middle of the food chain, their presence or absence causes a shift in patterns of predation. (Stebbins and Cohen 1995).

It is also important to consider metapopulations (a metapopulation is a network of semi-isolated populations with some level of regular or intermittent migration and gene flow among them, in which individual populations may become extinct but may be recolonized by other populations). This is especially important in areas that are being quickly developed because amphibian populations are becoming isolated (Casper 1998). Even where they are not isolated, conservation efforts need to keep in mind that individuals of many reptiles and amphibian species travel between sites, which increases genetic viability. This is also important where certain conditions (such as drought) might temporarily create population sinks.

7.6.4.2 Unique Characteristics of Amphibians and Reptiles

Blaustein and Wake (1995) did a good job of describing the special characteristics of amphibians:

"*Amphibians are valuable as gauges of the planet's health for a few reasons. First, they are in intimate contact with many components of their natural surroundings. For example, as larvae, frogs live in water, but as adults most find themselves at least partially on land. Their moist, delicate skins are thin enough to allow respiration, and their unshelled eggs are directly exposed to soil, water and sunlight. As larvae, they are herbivores and as adults, carnivores. Because amphibians sample many parts of the environment, their health reflects the combined effects of many separate influences in their ecosystems. Second, these animals are good monitors of local conditions because they are homebodies, remaining in fairly confined regions for their entire lives. What happens to frogs and their brethren is happening where humans live and might affect our species as well.*"

A unique characteristic of turtles is their longevity. Certain turtle species, such as wood turtles, can live as long as 40 years. This is very important given the fact that their annual productivity is often low and they do not reach maturity until they are 12 to 20 years old (Harding 1997). They lay eggs in sandy beaches, and these are often completely destroyed by predators. When adult turtles are collected and harvested, the remaining adults cannot replace the population with enough young to keep it viable. Collection of turtles for contaminant analysis has been discontinued for this reason (Brooks and others 1987 and Galbraith and others 1987); tissue from their eggs provides sufficient information to analyze contaminant levels.

Concerns about amphibian abnormalities have been in the news for the past five years, since the highly publicized 1995 discovery of deformed leopard frogs by middle school students in Minnesota. Since then, reports of abnormalities have surged, and a North American database and reporting system was established through the U.S. Geological Survey. The North American Reporting Center for Amphibian Malformations is now a repository of data about amphibian deformities. A web site has also been established to make this information easily accessible.

Experts have been conducting studies to try to determine the causes of these deformities, looking mainly at parasites, chemical contaminants, ultraviolet light, temperature, and other environmental factors. According to a recent report by Jamie K. Reaser (U.S. Dept. of State) in FROGLOG (a newsletter published by the International Union for the Conservation of Nature [IUCN] Declining Amphibian Population Task Force), it is unlikely that any one particular factor can be singled out as the cause. Different factors, such as chemical contamination, UV light, and parasites, operate by similar mechanisms, impacting similar ecological and developmental pathways to cause abnormalities.

7.6.4.3 Stressors of Amphibians and Reptiles

Stressors to amphibian and reptile populations are not clearly defined for the Lake Superior basin, but we will assume that the problems noted for the Upper Midwest and Canada are reflected in the Lake Superior basin. Stressors can be related to global problems and to local problems. Global problems include the increase of ultraviolet radiation from depletion of the ozone, acid precipitation, and bioaccumulation and transport of toxic chemicals such as DDT. Local problems are related to habitat loss and fragmentation, direct impact from chemical applications such as pesticides and herbicides, infectious diseases, and invasive species.

Habitat

Degradation and loss of habitat is a concern for many species, especially those dependent on wetland habitats. Degradation of wetlands is caused by eutrophication, pollution, scouring, addition of non-native fish, and loss of surrounding upland habitat. Loss of plant diversity due to invasion of exotic, invasive species can affect invertebrate populations, which can in turn affect the health of amphibians and reptiles (Casper 1998). Changes in land use surrounding wetlands and aquatic habitats may increase sedimentation rates (Casper 1998; Lannoo 1998). Clear-cutting may affect amphibians by changing soil moisture and acidity (Blymyer and McGinnes 1977). Woodlands that are managed by removing mature trees before they fall would not be suitable habitat for species that require litter and downed logs. Habitat fragmentation also causes loss of migration corridors and loss of the mosaic of wetland types that are often critical for amphibian life cycles, especially during drought years. Some species move from a seasonal pond to a permanent pond during dry years (Lannoo 1998). Migration corridors for reptiles are often disrupted by roads and trails, which can directly cause mortality of turtles (Oldfield and Moriarty 1994).

Ultraviolet Radiation (UV-B)

Ambient UV-B radiation can directly or indirectly kill some amphibian eggs under both field and laboratory conditions (Blaustein and others 1994, 1995, 1997). The depletion of the ozone has increased the amount of UV-B radiation striking the earth, which might be one of the reasons why amphibian populations in relatively pristine habitats are declining. The increase in UV-B radiation might have a synergistic effect, by making amphibians more susceptible to diseases.

Invasive Species

Zebra mussels and rusty crayfish alter the native prey base of areas they invade. Zebra mussels are voracious consumers and can drastically reduce the zooplankton population, leaving other native invertebrates little to eat. This can result in a drop in native invertebrate populations and less food for amphibian larvae. Rusty crayfish can wipe out native plants, which are used by invertebrates for food and shelter. The result is similar to zebra mussels, with a lower invertebrate population and less food for amphibians and reptiles.

The non-native plant, purple loosestrife, invades and dominates wetlands. These wetlands lose many microhabitats that are needed by invertebrates, causing a decrease in invertebrate diversity, which can negatively affect amphibians and reptiles in their aquatic stage.

Contaminants

Many studies have been done on contaminants and their effects on amphibians and reptiles, but most were laboratory studies, so little information is available about direct and indirect effects. More research needs to be done to better understand the direct, indirect, and cumulative effects of contaminants on reptiles and amphibians. Agricultural chemicals could be a significant cause of toxic effects, but this needs to be better investigated. Habitat fragmentation and destruction, compounded by pollution of some of the remaining, otherwise suitable habitat, as well as loss of the corridors between suitable areas, may have a devastating impact on the viability of amphibian metapopulations (Diana and Beasley 1998).

Some turtle species are long-lived and consume animal matter, making them especially susceptible to contamination by toxic pollutants (Shirose and others 1996).

Infectious Diseases and Parasites

Outbreaks of infectious diseases may be an important indicator of stress and environmental mismanagement. The effects of a disease might not be as dramatic if the population were not already stressed. The protection of suitable habitat and maintenance of a diverse gene pool are of critical importance in limiting the ultimate impact of a range of infectious agents (Faeh and others 1998).

Other

Introduction of fish, crawfish, and bullfrogs into naturally fishless ponds and wetlands can cause several problems. Introduced species may provide direct competition for food, and they may prey on the larval or fledgling stages of native amphibians and reptiles.

7.6.4.4 Management Efforts for Amphibians and Reptiles

All states within the Great Lakes and Ontario have protective laws and regulations that affect amphibians and reptiles (Harding 1997).

In Ontario, the Fish and Wildlife Conservation Act (FWCA) of 1997 lists all reptile species, with the exception of the common snapping turtle, as specially protected reptiles. The snapping turtle may be harvested within specified seasons and bag limits under the authority of an angling license. Of the 15 amphibian species found within the Ontario portion of the basin, only the salamander species and the gray treefrog are listed as specially protected under the FWCA. The frog species are not offered special protection, and, with the exception of the bullfrog, there are no harvest seasons in place. Bullfrogs may be harvested only within specified areas, seasons, and bag limits in Ontario.

The MN DNR keeps track of turtle harvest (those harvested for food). Turtles and frogs are collected by biological supply houses, under license by the MN DNR, without restriction. Minnesota law protects wood turtles and Blanding's turtles. A bounty system for rattlesnakes was removed in 1989. Minnesota Herpetological Society and the Nongame Wildlife Program are attempting to raise the awareness of conservation needs, to conduct inventories, and to protect important habitats.

The WI DNR regulates the taking of amphibians and reptiles. They specify seasons for some species of frogs and turtles and regulate the method of capture. They also limit the size of some species, such as snapping turtles. State threatened or endangered species may not be collected except by special permit.

The MI DNR protects species that are listed as threatened or endangered. Reptiles and amphibians that are listed as special concern by the MI DNR require a permit for collection (Lori Sargent, personal communication).

The IUCN established a Declining Amphibian Population Task Force (DAPTF) in 1991. The DAPTF includes a network of over 3,000 scientists and conservationists belonging to national and regional working groups, which cover more than 90 countries around the world. Ultimately, the DAPTF hopes to understand why populations are declining and develop conservation programs to stabilize them. A Great Lakes working group was established, which covers Minnesota, Michigan, and Wisconsin. Canada has established a Canadian Amphibian and Reptile Conservation Network as part of DAPTF.

Partners in Amphibian and Reptile Conservation is a public-private network that was established in 1999 to facilitate greater conservation efforts for amphibians and reptiles in North America, encouraging the use of partnerships to facilitate successful work. Modeled after the successful Partners In Flight program, its focus is to protect amphibian and reptile populations and habitats to "keep common species common." A Midwest Working Group formed in September 1999 includes the Lake Superior basin.

7.6.4.5 Current Monitoring Efforts

North American Amphibian Monitoring Program - This program was established by the Declining Amphibian Populations Task Force. It encompasses Canada, the United States, and Mexico. The purpose of the program is to collect information to monitor populations on a global basis. It includes frog calling surveys and terrestrial salamander monitoring. Monitoring protocols along random routes are established and conducted mostly by volunteers. Surveys in the Great Lakes region are coordinated by state and provincial agencies. Routes are included in the Lake Superior basin, but the data has not been compiled for the basin.

Ontario has several surveys that monitor amphibian populations, mostly frogs and toads. These programs are: Backyard Survey, Road Call Count Survey, Marsh Monitoring, and Adopt-A-Pond/Frogwatch. Backyard Surveys are conducted by volunteers who record species and calling intensity from their backyard or cottage on a daily basis. This program and the Road Call Count Survey is coordinated by the Canadian Wildlife Service. The Road Call Count Survey establishes routes that have stations from which observations are made. These surveys are also conducted by volunteers, who run the route three times during the spring and summer. The Marsh Monitoring Program's purpose is to monitor the health of wetland ecosystems in the Great Lakes basin, including 43 Areas of Concern around the Great Lakes. Marsh Monitoring includes an amphibian roadside survey, following the same protocols as the Road Call Count Survey mentioned above. Routes are also conducted outside of the Areas of Concern. This is coordinated by Bird Studies Canada.

Frogwatch USA is a new program established in February 1999. It is modeled after Frogwatch Ontario. Volunteers across the United States submit observations on their local amphibian populations by choosing and periodically monitoring a wetland site for calling frogs and toads. Adopt-A-Pond/Frogwatch in Ontario is coordinated by the Toronto Zoo and is similar to the Frogwatch USA program. This data is submitted to the Natural Heritage Information Centre of the OMNR. Both U.S. and Canadian programs allow citizens an opportunity to learn about the amphibian community in their area, as well as an opportunity to become involved in monitoring.

Some tribes and First Nation groups have initiated frog and toad surveys on native lands and project areas, including Bad River and Keweenaw Bay.

7.6.4.6 Gaps in Information about Amphibians and Reptiles

More routes and surveys are needed for all amphibian and reptile monitoring programs in the Lake Superior basin.

Monitoring protocols should be agreed to for amphibian and reptile surveys. Existing information for the Lake Superior basin should be compiled.

Few surveys are being conducted for reptiles, and those are usually very local or incidental. Monitoring programs should be established and followed.

Reasons for population changes for both amphibians and reptiles need to be identified.

7.6.4.7 Challenges for Amphibians and Reptiles

Most conservation and management actions have focused on vertebrate species that are either visible or harvested. Amphibians and reptiles can be highly observable at certain times of the year and are also harvested, yet they have been ignored in management plans in the past. An ecosystem approach to conservation should encompass habitat for all species, as well as all ecosystem functions. If the Binational Program is concerned with overall ecosystem health, then we need to pay closer attention to amphibians and reptiles in our inventories, planning work, actions, and monitoring efforts.

7.6.5 Invertebrates

7.6.5.1 Status and Trends of Invertebrates

About 90 percent of the nearly one million species of animals in the world are terrestrial or aquatic invertebrates (animals without backbones). In the Great Lakes region the larger, more easily seen invertebrates include insects and mollusks, such as snails and clams. Insects are the most diverse group and globally may have the largest collective biomass of all terrestrial animals. Yet, within the Lake Superior basin, we have little information on status and trends of the insect or terrestrial invertebrate populations. The groups are too large to encompass, and taxonomic problems have impeded the development of status and trend information.

Along with an appreciation of the interaction between plants and animals, the role of soil invertebrates, fungi, and microorganisms in ecosystem functioning must be understood. Interdependencies of every part of the biotic community, including the decomposers, must be taken into account. The complex spatial and temporal heterogeneity of habitats and species response to disturbance has to be understood. We have very little information on this, and new research must be initiated in this area.

7.6.6 Plants

7.6.6.1 Status and Trends of Plants

Green plants form the base for all animal life, and yet protection of plants in the ecosystem has not been associated with the protection of wild animals. The term wildlife has been traditionally used to refer to wild animals only. This gross misconception must be corrected. It is evident from the long list of rare and endangered plants in the Lake Superior basin (see habitat committee section) that the number of endangered plants far exceeds that of wild animals. For every threatened animal there are two or more endangered plants. This connection between wild plants and animals must be clarified and highlighted to the professionals and to the public. The importance of plants to the survival and well being of wild animals must be recognized and factored into the equation of wildlife conservation.

The habitat section of the LaMP includes status and trend information on plants and habitat, including threatened and endangered species. States and Ontario are interested in managing and protecting unique plant communities, representative plant communities, and also rare plants. Each state and Ontario has listed plant species that are rare or of special concern in their area. The federal agencies have also listed plants that are nationally threatened or endangered.

7.7 MOST SIGNIFICANT NEEDS

The following is a summary of the most significant needs (problems, challenges, and opportunities) facing terrestrial wildlife communities in the Lake Superior basin. The Binational Program will advocate and act as a catalyst to address these significant needs. Each need is tied to one or more strategies listed in Section 6. These needs have not been prioritized.

A. Habitat and land use changes have been very substantial in the basin, especially over the last 150 years. Terrestrial wildlife communities have shifted and changed in response, resulting in population increases for some species and population declines for others. The biggest challenges related to these changes are to 1) agree to the most feasible landscape mosaic that will support sustainable wildlife communities, and 2) work with partners to develop this landscape mosaic. This work must include an ecosystem approach to conservation and management.

Strategies that fit this problem/opportunity: A, B, C, D

B. Invasive species are causing major reductions in biodiversity where they dominate the landscape. Prevention and control is necessary to address this issue.
Strategies that fit this problem/opportunity: G, M

C. Little or no work has been done to compile existing information or to manage terrestrial wildlife communities on a basinwide basis.
Strategies that fit this problem/opportunity: H, I

D. Significant work has been done to recover some species in the basin; this work should continue and should be supported.
Strategies that fit this problem/opportunity: L

E. Forest management remains a critical activity that affects all wildlife communities, especially forest birds, amphibians, reptiles, and invertebrates. Forest structure, size of stands, and presence of large woody debris seem to be important characteristics for many wildlife communities. Planners and policy makers should work toward a landscape that encompasses all forest successional stages in various size parcels.
Strategies that fit this problem/opportunity: A, B, C, D

F. Terrestrial wildlife includes plants, animals and associated microorganisms. Many people think of wildlife in terms of individual species such as deer, grouse, ducks, and songbirds. Less often do they think of wildlife in terms of their functions in the ecosystem as a whole.
Strategies that fit this problem/opportunity: B, C

G. Additional work is needed to understand the role of invertebrates and microorganisms in terrestrial ecosystem health.
Strategies that fit this problem/opportunity: I, J

H. There is a great need to integrate the principles of wildlife community conservation into land use decisions at the federal, tribal/First Nations, provincial, state, local, and private planning level.
Strategies that fit this problem/opportunity: B, C, D

I. The effect of contaminants on many terrestrial wildlife species and populations remains unknown. Some species, such as bald eagles, are recovering as a result of decreasing contaminant levels, but many questions remain about the effect of contaminants on amphibians, reptiles, and mammals. Contaminants remain in the Lake Superior basin and are being transported from outside the basin.
Strategies that fit this problem/opportunity: E

K. Work should continue on understanding the long-term effects of herbivory on plants and animals.
Strategies that fit this problem/opportunity: J

L. GIS land cover classification is being initiated for the basin and should continue to be refined and updated at least every 10 years. This GIS land cover data needs to be linked to wildlife communities.
Strategies that fit this problem/opportunity: I, J

7.8 STRATEGIES

Meeting the mission and goals for terrestrial wildlife communities in the Lake Superior basin will require that a number of broad strategies be addressed. These strategies will be implemented not only through actions of participating agencies and organizations of the Lake Superior Binational Program (LSBP), but also through partnerships with many other individuals and organizations.

Projects that are committed to by LSBP members are identified in this chapter. Those projects in need of sponsorship and funding are also identified. Some projects could not be included at this time, and others are documented in the habitat chapter. The role of the LSBP will be to foster the implementation of those and other projects.

Many proposed projects are identified with inventory and monitoring strategies. This reflects the extent of the need for this work as identified by the partners of the Terrestrial Wildlife Community Committee. However, several strategies show no committed or proposed projects; these strategies will require action if we are to make progress.

STRATEGIES

A. Develop action-oriented regional and watershed-scale management plans. Support the implementation of protection and restoration actions recommended in these plans.

STRATEGY A COMMITTED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Whittlesey Creek National Wildlife Project	USFWS, DU, ALC, TU, others	Restore and protect habitat for anadromous trout and salmon of Lake Superior, protect habitat for waterfowl and other migratory birds, reintroduce coaster brook trout, and protect an important Lake Superior coastal wetland. About 40 acres of land were purchased in 1999; the plan is to eventually acquire 540 acres in fee title and several thousand acres in easement. The refuge is adjacent to the new Northern Great Lakes Visitors Center, a multi-agency regional visitor center.
STRATEGY A PROPOSED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Watershed Analysis and Restoration	Lake Superior NF's, with partners including MN DNR, MI DNR, WI DNR, GLIFWC, Tribes, etc.	Analyze watersheds and implement activities that will protect and maintain their health, and restore their composition, structure, and functions when impairments are found.
Ecology and Stability of Riparian-aquatic Interfaces of Boreal Forest Streams in NW Ontario	Lakehead University	Determine the structural and functional stability of the riparian buffer zone reserves along several boreal streams (approximately 500 sq. km.). A GIS-based model will be developed to predict the riparian zone structure and aquatic community characteristics from catchment-scale attributes.

B. Encourage land use planning efforts that are targeted at protecting and restoring wildlife while also maintaining economic viability of local communities.

STRATEGY B COMMITTED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Forest Management Planning	OMNR	For each Forest Management Unit in Ontario, a 5-year management plan must be prepared. The process includes extensive public consultation and detailed planning for timber extraction, road construction, protection and maintenance of wildlife habitat, tourism, and recreational opportunities.
Forest Management Planning	Bad River LSC, Red Cliff LSC, LSB National Parks, LSB National Forests, MN DNR, MI DNR, WI DNR	Prepare forest management plan. The process includes extensive public consultation and detailed planning for timber extraction, road construction, protection and maintenance of wildlife habitat, tourism, and recreational opportunities.

C. Foster an understanding of the relationship between individual (personal, organizational, and government agency) land use decisions and cumulative effects on ecosystem integrity. Compile Best Management Practices that are conducive to sustainable terrestrial wildlife communities.

STRATEGY C COMMITTED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Minnesota Loon Watcher Program	MN DNR	Lakeshore residents report on loon use of lakes, with notes on problems and concerns.
Lakescaping Workshops	MN DNR	Workshops are planned across the State of Minnesota. Two workshops to be held in St. Louis County. Workshops promote the need to protect shoreline and aquatic native vegetation around lakes in order to protect wildlife. Information is provided on native plant species and on landscaping with these species.

STRATEGY C COMMITTED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Wildlife Tourism Workshops	MN DNR	Workshops are planned across the State of Minnesota to promote awareness of alternative forms of tourism such as bird watching, nature photography, and wildlife watching. One workshop was held in Duluth in 1999. Two are planned for Ely and International Falls in year 2000. Workshops will be continued past 2000 pending funding. The objective of the workshops is to heighten the appreciation of natural and wild landscapes so these can be protected in spite of the increase in recreational development.
STRATEGY C PROPOSED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Post Logging Impact Study	Ottawa NF, MI DNR, GLIFWC, Tribes	Establish a post-logging study to assess the impact of timber harvesting on understory vegetation, based on the evaluation of historical studies to date.
Sharptail Grouse Habitat Video	WI DNR, UW Extension	Produce a public education video to increase awareness about the land management needs to provide suitable sharptail grouse habitat in the Douglas and Bayfield County barrens. In addition, build a demonstration site from current management near Solon Springs, WI.

D. Implement actions that consider all ecosystem components in planning and implementation. Demonstrate positive results of basinwide, landscape-scale, intergovernmental planning and collaboration.

STRATEGY D **COMMITTED PROJECTS**		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Upper Peninsula of Michigan Coastal Wetland Project	USFWS, DU, MI DNR, KBIC, BMIC, GLIFWC, TNC, WPBO, Village of L'Anse, Ottawa NF, NRCS, Private Landowners, UPRCD	This multi-phase landscape-scale project will protect, restore, and manage coastal wetlands and associated uplands in the Lake Superior and St. Mary's River watershed in Michigan. Phase I, initiated in 1999, includes nine focus areas in the Lake Superior basin of the UP of Michigan. Specific project activities include acquisition of fee title or conservation easements by government agencies or conservation organizations. The project will preserve 1,237 acres of wetlands and 11,537 acres of associated uplands. Also 7,847 feet of Lake Superior shoreline will be protected from development, 3,347 feet of which are identified as "essential breeding habitat" in the draft Piping Plover Recovery Plan. The project will benefit migratory birds, rare species, and unique habitats.
Superior Coastal Wetland Initiative	USFWS, Bad River Band of LSC, Red Cliff Band of LSC, WI DNR, TNC, DU, TU, Douglas, Bayfield, Ashland, Iron Counties Land Conservation District, NRCS, landowners, GLIFWC, Chequamegon Chapter of the Audubon Society	A landscape-scale coastal wetland preservation and restoration initiative on the southern shore of Lake Superior in Wisconsin. The project emphasizes land stewardship combined with protection and restoration of 8,180 acres of wetlands and 6,359 acres of uplands in the Lake Superior basin. Because many of the coastal wetlands in this region are relatively intact, the project will protect these areas through fee title and easement acquisition. The project will reduce pollution into tributary streams that feed these wetlands by focusing on upland activities that reduce sedimentation.

STRATEGY D PROPOSED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Bayfield Peninsula Binational Program Demonstration Project	USFWS, DU, USFS, NPS, GLIFWC, Red Cliff Band of LSC, local governments, private landowners, TNC, others	Expand on the Wisconsin Lake Superior Coastal Wetland Initiative to develop a demonstration project for protecting watersheds under the Binational Program. This would include watershed plan development for select watersheds in Bayfield County, including Whittlesey Creek, Fish Creek, Sand River, Raspberry River, and others These plans would use tools developed for the Lake Superior watershed, including habitat GIS work, monitoring of best bet indicators, and following the ecosystem approach to conservation. It would also overlap with the county land use plan being developed by Bayfield County.

E. Support contaminant load reduction efforts, track contaminants within "best bet" wildlife species, and encourage the development of biological indicators for air quality monitoring.

STRATEGY E COMMITTED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Population Monitoring of Otter and Mink and their Roles as Biosentinels	Bad River Tribe, WI DNR	Thirty-two river otter and 30 mink will be live-trapped and implanted with transmitters to determine behaviors, movement patterns, home ranges, and territories in the Bad River Watershed. Contaminant profiles for standard pesticides, PCBs, and heavy metals will be determined from live-trapped animals with known territories, as well as from carcasses from trapped animals.
Upper Great Lakes Loon Biomonitoring Program	BRI and partners too numerous to list	Monitor population dynamics and reproductive success and conduct related studies (contaminant loading) using color-marked loons in the Upper Great Lakes region.
Mercury Levels in Wildlife within Sargent Lake Watershed, Isle Royale NP	NPS, USGS BRD, MTU, UW-Madison, Biodiversity Research, Inc	Determine Hg levels in loons, moose teeth, mice, fish/water/sediments of Sargent Lake watershed, and in human baby teeth in U.P. of Michigan

STRATEGY E COMMITTED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Assessing the Ecological Risk of Mercury to Wildlife in the north central U.S.	WI DNR, USGS BRD, UW-Madison	The common loon serves as an indicator species for several studies investigating the impact of mercury on wildlife in the Lake Superior and Upper Mississippi River watersheds. Project goals are to measure mercury exposure levels in common loons across the region, to determine mercury exposure levels associated with negative effects on common loon, and to develop a toxicokinetic model to predict loon mercury exposure as a function of prey-mercury concentrations.
STRATEGY E PROPOSED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Determine the Status and Levels of Toxic Chemicals in Colonial Birds within the Lake Superior basin	NPS, USGS-BRD, MN DNR, WI DNR, MI DNR, USFWS, Pukaskwa National Park, OMNR, CWS, Parks Ontario, EC	Utilize new and existing data to determine the status and trends of colonial birds within the Lake Superior basin and test herring gulls and double-crested cormorants for levels of toxic chemicals.
Great Lakes Bald Eagle Biosentinel Monitoring Program	WI DNR, USFWS, U.S. EPA, NPS, USGS BRD, EC, CWS, State and Provincial natural resource agencies	Conduct aerial surveys and sample bald eagle nestling blood and unhatched eggs at Great Lakes nest sites to quantify trends in contaminant exposure and identify nest sites where productivity is impaired by exposure. Early warning monitoring plan for future toxic threats. Methodologies developed will be used as the protocol for implementation developed by a multiagency workgroup.

F. Inventory all levels of the biotic community, assess wildlife needs, and develop actions for protection, maintenance, and restoration, with priority attention to groups for which little is known (gaps).

STRATEGY F COMMITTED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Furbearer Scent Post Survey	MN DNR	Annual survey. Results are used to set trapping limits for bobcat, otter, pine marten, and fisher. Model populations. Provide data on Otter and bobcat to CITES.
Woodcock Survey	MN DNR, USFWS	Annual survey to obtain an index of abundance of population to set harvest levels.
Ruffed Grouse Drumming Count	MN DNR	Obtain an index of abundance of ruffed grouse. This survey is important for public relations with hunters.
Ontario *Odonata* Summary	TEA	Annual summary of *Odonata* (dragonflies and damselflies) seen in the province each year.
Ontario *Lepidoptera* Summary	TEA	Annual summary of *Lepidoptera* (primarily butterflies) seen in the province each year.
Bear Food Production Survey	MN DNR	Annual questionnaire that is sent to various field biologists to estimate the abundance of plant species important in the diet of black bear. Data correlates well with number of bears that hunters observe in the field and with hunter success.
Black Bear Population Index	OMNR	Annual bait line surveys in a number of Wildlife Management Units.
Rare Plant/ Community Surveys	OMNR (NHIC)	Periodic surveys to determine the extent, status, and composition of various rare plant communities in Ontario. Has included surveys within the Lake Superior basin.
Canada Lynx and Pine Marten Monitoring and Habitat Improvement	Ottawa NF, MI DNR, MITA	Identify potential habitat for lynx and marten (separately) on the Ottawa NF. Inventory 40,000 acres of the mostly likely habitat and quantify the results using the previously developed habitat identified on GIS. Prepare a report on the results and develop management guidelines.

STRATEGY F **COMMITTED PROJECTS**		
Baseline Inventory of Amphibians and Evaluation of Catastrophic Deformities	NPS	Survey the major wetland areas within the basin for amphibians, determine their relative abundance, distribution, and the extent of deformities. Document important habitats and rare species. Develop protocols for long-term monitoring.
Survey *Lepidoptera* within the Apostle Islands NL Sandscape State Natural Area	NPS, Eastern National	*Lepidoptera* are increasingly being recognized as sensitive indicators of the integrity and continuity of native ecosystems and can provide a measure of successful habitat management. This project will survey lepidopterans (butterflies and moths) within the Apostle Islands NL Sandscape State Natural Area. Four high-quality sandscapes are included in the survey.
Migratory Bird Survey	NPS	The southern end of Outer Island and Long Island (Apostle Island NL) are important concentration points for migratory birds. Surveys are conducted approximately every five years.
Aerial Moose Inventory	OMNR	Aerial population survey of each Wildlife Management Unit (WMU), conducted on a three year rotation.
Winter Track Counts	MI DNR	Winter track count routes are established on trails throughout the northern 2/3 of Michigan. Identification and number of tracks are recorded for each wildlife species on the trail route. Counts are conducted once each year.
Bird Migration within the Lake Superior basin	MAS, LSSU, Hawk Ridge (Duluth), LPBO, TCBO	Volunteers record the species and number of migrating birds during spring and fall migration at various observation points.
Annual Trapper Questionnaire	OMNR, OFMF	Annual questionnaire to determine trapper estimates of wildlife population levels and population change.
Wildlife Observation Booklets	OMNR	Observation checklist program to supplement wildlife distribution range mapping.
Small Mammal Monitoring	OMNR	Fall live-trapping lines as index to small mammal population levels and population change.
Waterbird Count	WPBO	Conduct counts of waterbirds, including loons, migrating past Whitefish Point (eastern Lake Superior) during spring and fall.
Project Feeder Watch	OMNR, BSC	Bird feeder surveys to monitor winter resident birds.

STRATEGY F COMMITTED PROJECTS		
Loon Watch	SOEI, Northland College, MI LPA	Conduct educational programs about loons and lakeshore protection. Conduct annual and five-year surveys to monitor productivity and population size.
Rare Carnivore Inventory	Hiawatha NF, MI DNR, Pictured Rocks NL	Conduct a comprehensive inventory covering approximately 1,000,000 acres.
Avian Migration Monitoring	BSC, OMNR	Monitoring of migrant songbirds at Thunder Cape, Lake Superior, and Long Point, Lake Erie.
Ruffed Grouse Survey	MI DNR, WI DNR, MN DNR	Count the number of drums and the number of individual ruffed grouse drumming on survey routes throughout Michigan. Information obtained is used as an index to ruffed grouse numbers.
STRATEGY F PROPOSED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Determine the Status and Trends of Breeding Birds within the Lake Superior basin	NPS, USFS, USGS-BRD, USFWS, NRRI, OMNR, CWS	Use existing survey data from various agencies and entities to determine the status and trends of breeding birds within the Lake Superior basin. Gaps in survey data and recommendations for monitoring will be identified.
Study Fall Bird Migration within the Lake Superior basin	NPS, USFWS, National Audubon Society, OMNR, CWS, USGS-BRD, NRRI, USFS	Conduct fall migratory bird surveys at key locations within the Lake Superior basin, including Outer Island (in Apostle Islands NL). Determine the status and trends of migratory birds within the Lake Superior basin using new and existing data.
Determine the Status and Trends of Amphibians within the Lake Superior basin	NPS, USGS-BRD, USFWS, WI DNR, MN DNR, MI DNR, Milwaukee Public Museum, NRRI, OMNR, CWS, USFS	Assemble data from monitoring programs and studies to determine the status and trends of amphibians within the Lake Superior basin. Identify data gaps and provide recommendations for a Lake Superior basin wide monitoring program.
Ontario Breeding Bird Atlas	OMNR, CWS, BSC, FON, OFO and others	Second Ontario Breeding Bird Atlas planned for 2001-2005 to document ranges and relative abundance of breeding birds in Ontario and determine any changes from first atlassing project conducted in 1981-1985.
Breeding Bird Census	Ottawa NF, Educational Institution	The Ottawa Breeding Bird Census has been an ongoing project. The Forest is searching for additional partners, including an educational institution, to formalize the yearly event.

STRATEGY F COMMITTED PROJECTS		
Non-vascular Plants, Invertebrates, Fungi and Micro-organisms Inventory/Analysis	Lake Superior NF's, MN DNR, MI DNR, WI DNR, GLIFWC, Tribes, etc.	Conduct inventory and status/trends and problem analysis for selected non-vascular plants, invertebrates, fungi and micro-organisms.
Five-year Songbird and Herptile Survey of WI Wetlands	WI DNR	Collect baseline data.
Great Lakes National Parks Inventory and Monitoring Initiative	NPS, potentially numerous others	Proposed program to complete critical inventory needs for Great Lakes national parks for vascular plants, amphibians, birds, mammals, and fish.

G. Inventory extent of exotic, invasive, terrestrial wildlife species and implement actions to prevent, remove, or control them in the Lake Superior basin.

STRATEGY G COMMITTED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Control of Invasive Plants in Pictured Rocks National Lakeshore	Pictured Rocks NL	Use herbicide and mechanical controls to suppress invasive plant populations within park boundaries.
Public Education on Invasive Species	GLIFWC, NRCS	Educate the public about the consequences of invasive exotic species in the northern ecosystems. Displays, slide shows, pamphlets, and posters have been designed and distributed; presentations have been made to county fairs, 4-H groups, and civic organizations. Professional slide shows have been developed for use by others. Extensive use has been made of the Internet and its resources.
Exotic Plant Control Project	GLIFWC, U.S. EPA	Conduct an assessment of invasive exotic species that may be invading the ceded territories. This assessment will consist of literature search and expert interviews. Once the assessment is completed, a system of prioritization will be developed to identify high priority sites for control efforts.
Purple Loosestrife Control	GLIFWC, BIA, NRCS, TNC, Bad River Band of LSC	Develop and implement an integrated purple loosestrife control program in the Bad River Watershed. Loosestrife was surveyed in the watershed in 1994, followed by a 5-year control effort using herbicides. A repeat survey will be conducted in the summer of 2000.
Survey and Ranking of Nonindigenous Invasive Plants in Four National Lakeshores along the Upper Great Lakes	USGS-BRD, Pictured Rocks NL, Sleeping Bear Dunes NL, Indiana Dunes NL, Apostle Islands NL	Objectively quantify the abundance of exotic plants in four National Lakeshores.

STRATEGY G PROPOSED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Rusty Crayfish Reduction and Control	Ottawa NF, MI DNR, UNDERC	Reduce the numbers of rusty crayfish through policy and law changes. Promote commercial utilization of rusty crayfish as a means of reducing their numbers and their negative impacts on aquatic vegetation and native species.
Invasive Plant Species Inventory and Eradication	Ottawa NF, Northwoods Weed Council (Ottawa NF, Chequamegon Nicolet NF, Hiawatha NF, Apostle Islands NL, TNC, GLIFWC, LCO Tribe, WI DNR)	Field inventory to support non-native invasive plant control on the forest, particularly in sensitive and high visibility areas, including riparian zones. Project includes public education component. Project conducted on a cooperative basis across the subregion.

H. Develop, test, and implement monitoring protocols, sampling procedures, and data handling for identified high priority "best bet" indicators. Network this monitoring and compile the information long-term and basinwide.

STRATEGY H COMMITTED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Frog and Toad Monitoring	NPS, WI DNR	Frogs and toads are monitored within the Apostle Islands NL three times annually at ten survey sites (five on islands, five on the mainland). This survey is also part of the Wisconsin Annual Frog and Toad Survey.
Forest Bird Monitoring	OMNR, CWS	Point-count surveys to monitor forest bird populations.
Nocturnal Owl Surveys	OMNR, BSC	Roadside broadcast survey to monitor owl population trends.
Amphibian Road Call Counts	OMNR, CWS	Roadside survey to monitor frog and toad abundance levels.
Salamander Monitoring	OMNR	Artificial cover object surveys as an index to population levels and distribution.
Canadian Lakes Loon Survey	Bird Studies Canada	Volunteers conduct surveys of a lake or section of a lake to record number of adult loons, number of terrestrial pairs, and number and age of chicks.
Biological Monitoring Program, Isle Royale NP	NPS, SOEI, Biodiversity Research, Inc, volunteers	Annual surveys of forest songbirds (Breeding Bird Survey); common loons/productivity; frogs and toads; bald eagle and osprey productivity.

STRATEGY H COMMITTED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Breeding Bird Census	Ottawa NF, Volunteers	Annual surveys of breeding bird habitats and population counts.
Breeding Bird Survey	USGS, State DNR's, USFS, USFWS, Province of Ontario	Standardized roadside count of singing male birds along randomly selected routes in Michigan. Each route is 20 miles in length and has 20, 3-minute listening stops.
Trapper Booklet Program	OMNR, OFMF	Booklet to gather information on trapping effort (three trap set) and harvest for beaver, otter, marten, fisher, lynx, and wolf.
Breeding Bird Survey	Chequamegon Nicolet NF, Chippewa NF, Superior NF, NRRI, State of Minnesota	Thirteen hundred permanent points are established and will be sampled annually on the three national forests.
Frog and Toad Survey	MI DNR, WI DNR, OMNR	Identify calls of frog and toad species and record numbers heard, using a standardized methodology as an index to distribution and abundance. Surveys are conducted annually.
Develop Monitoring Protocols for Long-term Forest Vegetation Monitoring	NPS, USGS-BRD	Determine how forest communities in the lakeshore are changing through time, both old-growth and second-growth, and the extent of natural restoration of forest communities following logging. The project focuses on old-growth forest remnants within the Apostle Islands NL, including one area that was logged and not burned, and another area that was burned and logged.
Monitor Colonial Nesting Birds	NPS, WI DNR	Apostle Islands NL provides important habitat for colonially nesting herring gulls, double-crested cormorants, and great blue herons. The NL, in cooperation with the Wisconsin DNR, has been monitoring colonial birds in the islands since 1974. Twice every five years the two largest colonies in the lakeshore are monitored, and the entire lakeshore is monitored every five years.
Bald Eagle/Osprey Survey	MI DNR	Aerial survey flights are conducted twice each year. The first flight is conducted at the appropriate time to determine nests that are occupied by eagles. The second flight is timed to determine productivity. Secondarily, information on occupied nests is provided to eagle banders to expedite banding operations.

STRATEGY H PROPOSED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Implement High Priority "Best Bet" Monitoring	All federal, state and provincial agencies, GLIFWC, Tribes, and First Nations within the LSB	Develop and implement a coordinated monitoring effort for high priority "best bet" indicators as identified at the Lake Superior Monitoring Workshop (Oct. 1999).
Common Loons as Indicators of Recreational Use Impacts	NPS, Biodiversity Research, Inc, SOEI, USGS BRD-Ashland	Use common loons as an indicator of ecosystem health and impacts from human recreational use, possibly by tracking loon productivity.
Furbearer Monitoring Program	WI DNR	Obtain baseline data on furbearer populations and habitats.

I. Beyond "best bet" indicators, develop an integrated, community-based wildlife program to monitor ecosystem health.

STRATEGY I PROPOSED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Wilderness Monitoring and Rehabilitation	Ottawa NF, State DNR's, Other NF's and federal agencies, GLIFWC, Tribes	Look at opportunities to use wilderness as a baseline tying to species monitored by the states, federal, tribal, and other agencies. Concerns include the impact of recreation on nesting loons, eagles, and fishery resources. Develop monitoring plan and subsequent proposed action strategies as appropriate.
Survey for Ecosystem Approaches to Wildlife Community Monitoring	TWCC, GLIFIWC, USFS, NPS, USGS BRD, NRCS	One of the goals of the TWCC is to developed a community-based monitoring program to track proper ecosystem health and functioning rather than the more traditional single species monitoring protocols now in place. Other agencies and organizations across the U.S. and Canada are attempting to do the same thing. This project will conduct a survey of these agencies and organizations in an attempt to understand their progress. Information regarding monitoring objectives, protocols, and results will be solicited and summarized. TWCC will use this information to develop a similar monitoring program applicable to the Lake Superior basin.

J. Conduct assessments and implement conservation strategies for important terrestrial wildlife species and communities.

STRATEGY J COMMITTED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
White-tailed Deer Fawn Survival as Related to Winter Severity and Nutritional Condition of Does	MN DNR	Assess the impact of winter severity on the nutritional condition of female white-tailed deer and its relationship to subsequent fawn production and survival. This study will enhance our understanding of the functional relationship between winter weather and population performance of white-tailed deer in Minnesota and will provide a biological basis for deciding if and when the DNR should provide emergency feed to deer, as mandated by the Minnesota Legislature.
Isle Royale NP Moose Browsing Project	NPS, MTU	Effects of moose browsing on vegetation and the relationship to natural fire regime at Isle Royale.
White-tailed Deer Movement in the Upper Peninsula	MI DNR, UP Whitetails, Champion International, various sportsman's groups	White-tailed deer are captured during the winter when concentrated in deeryards. Deer are trapped in box traps and marked with ear-tags, which are uniquely colored for the yarding complex and numbered specific to the deer. Observations of marked deer are recorded at DNR offices and forwarded to a central location for compilation. Maps are generated to show tagging and observation locations.
White-tailed Deer Pellet Group Surveys	MI DNR	Information about deer pellet group density is useful as an index to the abundance of deer. A stratified random sample of pellet survey plots are established every 5 years.
Status of Vegetation and White-tailed Deer in Beaver basin, Pictured Rocks National Lakeshore	NMU, GLSC, Pictured Rocks NL	Assess the impact of deer herbivory on vegetation in the Beaver basin at Pictured Rocks NL.
Predator Interaction Study	GLIFWC, Chequamegon Nicolet NF, NCES, WI DNR, UWSP	Investigation into the spatial interaction among sympatric carnivores. Radio telemetry techniques employed to study movements, territoriality, and home range characteristics of bobcats, fishers, and American martens.

STRATEGY J PROPOSED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Colonial Nesting Bird Restoration	WI DNR	Restore colonial nesting birds and determine the negative impacts from the increase of herring gulls.
Deer Herbivary Impact Study	Ottawa NF, MI DNR, GLIFWC, Tribes, etc.	Establish a herbivary study to assess the impact of deer browsing on understory vegetation, based on the evaluation of historical studies to date.
Conservation Assessments, Strategies and Implementation for Wildlife Species	Lake Superior NF's, MN DNR, MI DNR, WI DNR, GLIFWC, Tribes	Complete conservation assessments and implement protection and/or restoration strategies for following species: dwarf bilberry, northern blue butterfly; *Botrychium* ferns; northern goshawk; red-shouldered hawk; ram's-head lady slipper; Canada lynx; butternut; American ginseng; boreal owl; lichens.

K. Evaluate restoration projects and restoration ecology research that addresses terrestrial wildlife in order to link successes to specific restoration features and future needs.

STRATEGY K PROPOSED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
American Marten Recolonization Across Landscapes	GLIFWC, USFS North Central Experimental Station, WI DNR	American martens were extirpated in Michigan and Wisconsin during the early 1900s. Reintroduction efforts have started new populations in these states. However, martens have not dispersed from release sites to recolonize new areas. This lack of dispersal is not understood but may be due to the lack of habitat and appropriate corridors. This study will attempt to document dispersal characteristics of American martens and to determine the type of corridors used for dispersal. This study will supplement information already gathered about home range and micro-habitat selection patterns.

L. Protect, enhance, and restore species of concern such as caribou, moose, colonial waterbirds, boreal owl, northern goshawk, white pine, and hemlock.

STRATEGY L COMMITTED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Woodland Caribou Study	OMNR, Laurentian University, Forest Industry	A multi-year study to look at the seasonal movements and habitat use (calving sites, wintering areas, summer habitat) of woodland caribou in northwestern Ontario.
Moose Population Assessment	MI DNR	Moose will be captured in the western UP using specially designed nets deployed from a helicopter. Moose are fitted with radio transmitters, and this marked population is followed to identify pregnancy and natality rates of female moose by age class. Radio-marked sample will be used to identify age- and sex-specific mortality, estimate dispersal rates and distances, and evaluate potential factors limiting moose population growth.
Northern Goshawk Monitoring	Hiawatha NF, Ottawa NF, NMU, Clemson University, MINGF, Seney NWR	Transmitters were placed on 6 northern goshawks for monitoring using radio telemetry during different times of the year.
Wild Rice Restoration	Ottawa NF, GLIFWC	Approximately 10 acres of wild rice were seeded at five sites.
Aerial Moose Survey	MN DNR	Survey to estimate numbers and recruitment of moose in northeastern Minnesota. The survey data is used to help set hunting seasons.
Determine Status, Distribution and Appropriate Trapping Levels of Fisher	NPS	Determine the distribution and abundance of fisher at Apostle Islands NL, determine whether existing state harvest models are appropriate; develop protocols for monitoring.
Update Regional Forester's Sensitive Species List, Eastern Region, USFS	USFS, with input and assistance of many interested parties	Update the regional forester's sensitive species list for the Eastern Region, including all Lake Superior National Forests.
Trumpeter Swan Reintroduction	Ottawa NF, KBIC, MSU, USCG, MI DNR, USFWS, UPPCO	Fifteen swans have been released on the Ottawa NF with another release planned for 2000. Released birds were radio-collared and are being monitored.

STRATEGY L PROPOSED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Wild Rice Restoration	Ottawa NF, GLIFWC, LVD Tribe	Restore wild rice at sites where it historically occurred and introduce it at new sites with suitable habitat.
Conservation Assessment and Strategy for Woodland *Botrychium* Species	Ottawa NF, Chequamegon Nicolet NF, Hiawatha NF, MI NFI	Develop a conservation assessment (status report) for rare *Botrychium* species through literature searches, consultation with experts, field surveys, and database queries.
Trumpeter Swan Reintroduction	Ottawa NF, KBIC, MSU, USCG, MI DNR, US FWS, UPPCO	Continue work to reintroduce trumpeter swans to the Ottawa NF. Obtain and radio collar up to 12 birds. Monitor their activity and range.
Moose Research	MN DNR, environmental education	A radio telemetry project to determine annual variability in moose survival and reproduction and develop educational opportunities for students in local community colleges.
White Pine Regeneration	USFS, Gunflint RD, FSL Rhinelander, WI DNR, MN DNR, WPS	Identify white pine locations within ECS Subsections 212LB on LTA's 01 and 02; make grafted collections; begin controlled breeding and out-planting of enclaves.

M. Encourage the use of native species for all projects requiring vegetation restoration.

STRATEGY M PROPOSED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Native Plant Restoration - Nursery Production	J.W. Toumey Nursery, Ottawa NF, MI DNR, GLIFWC, Tribes	Develop growing stocks of selected native plant species for soil and water protection, species recovery, and restoration of native stock to watersheds.

N. Identify population issues and implement recovery actions for threatened and endangered species.

STRATEGY N COMMITTED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Bald Eagle Monitoring	NPS, WI DNR	In cooperation with the Wisconsin DNR, an overflight is conducted in April to determine the number of occupied eagle nests. A second overflight is conducted in June to determine productivity. Eaglets are banded following the second overflight.
Gray Wolf Management in the Lake Superior Region: Voyageurs NP and Pictured Rocks NL	Voyageurs NP, Pictured Rocks NL, MTU	Assess the movements and habitat use of wolves in the two national parks. Determine impacts of visitors on wolf population dynamics, demographics, sustainability, and behavior.
Bald Eagle Monitoring	Chequamegon Nicolet NF, US Navy	Forty-two known eagle territories were monitored through aerial, fixed-wing surveys. 1998 results showed 31 active territories producing 35 young.
Kirtland's Warbler Survey	MI DNR, USFWS	Suitable habitat is visited each year, in early summer, to listen for singing male Kirtland's Warblers.
Piping Plover Survey	MI DNR	Areas of Great Lakes beaches known to have had nesting piping plovers are searched each year to confirm use. Suitable areas of Great Lakes beaches are also searched to identify potential new nesting areas.
Gray Wolf Monitoring	Chequamegon Nicolet NF, US Navy	Fourteen wolf packs were monitored throughout the year through trapping, radio-collaring, radio-tracking, track and howling surveys.
Piping Plover Monitoring	NPS, WI DNR, Bad River Tribe, USFWS	Apostle Islands NL provides nesting habitat for piping plover, a federally endangered species. After a hiatus of 15 years, piping plover began nesting in the Lakeshore in 1998. Monitoring is conducted in May to determine nesting status. If nesting occurs, protective actions are taken, such as erecting a nest exclosure. Intensive monitoring is done between egg laying and hatching.
Upper Peninsula Wolf Survey	MI DNR, USFWS	Winter track survey and capturing of wolves to attach radio collars. Goal is to have at least one member of each pack collared.

STRATEGY N **COMMITTED PROJECTS**		
Kirtland's Warbler Nesting Habitat Improvement and Monitoring	Hiawatha NF, MI DNR, USFWS	Over 25 acres of jack pine were planted in newly regenerating stands. Seedlings were planted in dense pockets to simulate conditions after wildfire.
Kirtland's Warbler Recovery	USFWS, MI DNR, others	Recover Kirtland's Warbler populations to meet recovery team goals. 19 males were counted in the Upper Peninsula of Michigan in 1999. Work in the Lake Superior basin includes census of singing males and banding to determine site fidelity and survivorship. Habitat protection and management will follow once site fidelity is better known.
Piping Plover Habitat Protection	USFWS, private landowners, local governments, NGOs	A program has been developed and funded to advance recovery of Great Lakes piping plovers by protecting shoreline habitat through cooperation with private landowners and local governments.
STRATEGY N **PROPOSED PROJECTS**		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Kirtland's Warbler Habitat Improvement	Ottawa NF, MI NFI, MI DNR	Complete Kirtland's Warbler surveys on 5,000 acres. Trap cowbirds at five locations. Inventory habitat on 8,000 acres. Complete management plans for all jack pine stands in the KW management area. Prescribed burn on 300 acres.
Lynx Analysis	Hiawatha and Ottawa National Forests, MI DNR and Michigan State University	Review land use/cover change over time to assess lynx habitat change/ corridor use, validate the lynx habitat suitability model, map temporal trends in lynx habitat quality, and assess how land use/cover changes and habitat quality may affect lynx movement, distribution, and metapopulation structure in the UP of MI.
Complete a Field Guide for Identification of All T&E Species	Ottawa NF, MI DNR, GLIFWC, Tribes	Complete a field guide for the identification of all T&E plants and animals in the Lake Superior basin. While some field guide development has occurred in Michigan for plants, a full field guide is needed for the Lake Superior basin. The intent is to have the field guide in the hands of field employees of agencies and organizations working in the basin.

STRATEGY N COMMITTED PROJECTS		
Determine Causes of Low Eagle Productivity along the Wisconsin Shoreline of Lake Superior	NPS, USGS-BRD, WI DNR	Determine if there are correlations between eagle productivity and productivity of major prey items.
Peregrine Falcon National Survey	OMNR, variety of naturalist groups	Survey of Ontario range to confirm nesting and successful breeding of reintroduced falcons. Part of a national survey that occurs every 5 years.
Upper Peninsula Timber Wolf Alliance (TWA) support	Ottawa NF, MI DNR, USFWS, SOEI	Support to TWA in the Upper Peninsula of Michigan in context of speakers bureau workshops, wolf boxes, school presentations, community organizations, hunter contacts, and other educational activities.

7.9 SIGNIFICANT ACCOMPLISHMENTS

Much work has been done and much work continues in support of the strategies to protect and restore the health of terrestrial wildlife communities in the Lake Superior basin. Much work has been done through habitat projects that are listed in the habitat chapter. Examples of other projects are listed below, but this list is not inclusive of all successful progress being made in the Lake Superior basin. Tracking our successes will be one important measure of progress toward the goals of the Terrestrial Wildlife Community Committee.

COMPLETED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Woodcock Nesting and Breeding Habitat	Ottawa NF, MI DNR, OIA, RGS, Trale UP, Sierra Club	Fourteen acres of new openings were created and trails improved in the Harris Creek Universal Access Area. A total of 219 acres of existing trail and opening maintenance, shrub planting, brush removal, and mowing were completed.
Great Lakes Bald Eagle Biosentinel Research Program	WI DNR, Apostle Island NL, UW-Madison, USFWS Green Bay, U of MN	Monitored and conducted research on reproductive success and contamination exposure of Lake Superior and Lake Michigan bald eagles. Findings published: Dykstra, C.R. and others 1998. J. Great Lakes Research 24:32-44.

COMPLETED PROJECTS		
Project Name	**Proponent(s), including partners**	**Brief Project Description**
Growth Response and Fruit Production of Blueberry (*Vaccinium* spp.) Following Forest Vegetation Management by Brush Cutting, Herbicide, and Prescribed Fire	Lakehead University	Study conducted in a young jack pine plantation showed that low-bush blueberry (*Vaccinium angustifolium*) is more sensitive than velvet-leaf blueberry (*V. myrtiloides*) to Roundup herbicide (glyphosate). The latter has higher morphological plasticity and more efficient vegetative regeneration strategy. Impacts of herbicides on berry-producing plants have direct implications on berry-eating wildlife in the Lake Superior basin.
Floristic Composition and Diversity of an Old Growth White Pine Forest in Greenwood Lake, NW Ontario	Lakehead University	Understory and overstory species diversity, habitat heterogeneity, and composition of this rare 300-year-old 162 ha. white pine forest was studied. The age class distribution of the tree species was determined. Research is also underway to study the natural regeneration of white pine in an adjacent area burned by a natural fire in 1992. It is very important to establish biodiversity and forest regeneration monitoring plots in this rare old-growth forest in the Lake Superior basin.
Puskaskwa Predator-Prey Study	Parks Canada	A multi-year study to look at the interactions among wolves, moose, and caribou in Pukaskwa NP.
Peregrine Falcon Reintroduction	OMNR, variety of naturalist groups	Hacking program to reintroduce peregrine falcons to a number of sites within their historical range.
Root-shoot Characteristics of Riparian Plants in a Flood Control Channel: Implications for Bank Stabilization	Lakehead University	This study, conducted in the Neebing-MacIntyre floodway channel in Thunder Bay, showed that native riparian plants selected on the basis of their root-shoot characteristics can be used in restoration projects. Another study conducted in the floodway examined plant colonization along the banks of the floodway ten years after construction.
Community-based Biodiversity Conservation in the Western Lake Superior basin	NAFEC, OMNR (NHIC), TNC	Identify key areas for conservation, share site conservation planning expertise with local community groups, and help these groups begin site conservation activities on their landscapes.

7.10 TERRESTRIAL WILDLIFE COMMUNITY COMMITTEE NEXT STEPS

The work of the Terrestrial Wildlife Community Committee between publication of the LaMP 2000 and the LaMP 2002 effort is identified below. The committee intends to be actively engaged in implementing the terrestrial wildlife strategies through support of priority projects, with the idea of reporting progress in the LaMP 2002 process.

A. Track and revise projects identified in the LaMP 2000.

B. Implement projects funded within the Terrestrial Wildlife Community Committee.

C. Maintain a priority list of projects for restoration/protection/rehabilitation of terrestrial wildlife in the Lake Superior basin.

D. Encourage, support, and develop projects that address strategies that are currently poorly represented.

E. Actively seek proponents, potential partners, and adequate funding for proposed terrestrial wildlife projects identified in the LaMP 2000.

F. Encourage development of monitoring protocols, sampling procedures, and data handling processes for selected “best bet” terrestrial wildlife indicators. Survey monitoring systems that are ecosystem-based for wildlife communities.

G. Work with the communications committee in LSBP to develop and implement a communications package, which would explain LSBP goals, objectives, and project needs to the practitioners of restoration/protection/rehabilitation in the basin. Offer technical and/or administrative assistance.

H. Produce quality articles about restoration/protection/rehabilitation activities in the basin. Distribute to publications of participating Terrestrial Wildlife Community Committee organizations, magazines, and other outlets.

I. Continue to work with the SWG of the LSBP to ensure delivery of the LaMP 2002 for Lake Superior.
   - Identify resource needs for the operation of the committee.
   - Update indicators and targets from LaMP 2000.
   - Identify existing programs and assess whether they are adequate to achieve committee goals.
   - Recommend new program requirements.
   - Complete and update the theme chapter for terrestrial wildlife based on public review and new information/need for revision.
   - Update and keep current the Terrestrial Wildlife section of LSBP web sites.

- Participate in and assist in the development and implementation of the overall LSBP communications strategy.
- Develop a scripted program with audio-visual aids for LSBP participants to take to stakeholder meetings.

J. Actively seek existing or proposed terrestrial wildlife projects for inclusion in the program.

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ADDENDUM 7-A
ECOSYSTEM CONSERVATION EXAMPLE - WOODLAND CARIBOU

Ecosystem Conservation Example - Woodland Caribou - Managing a Declining Keystone Species (OMNR 1999; Racey and Armstrong 1996)

The Ontario Ministry of Natural Resources (OMNR) initiated a strategy for woodland caribou conservation in the mid-1990s. The Ministry recognized that the caribou was a resource that was not considered or conserved by existing forest management practices and, as a result, its range was continually decreasing. Concurrently, the OMNR was shifting its policies toward sustainable development and an ecosystem management approach. Several policy principles were developed that speak to that philosophy:

- Human activity that affects one part of the natural world should never be considered in isolation from its effects on others.
- We must recognize the value of a diversified economy based on the preservation of the diversity of the natural world.
- Our understanding of the way the natural world works—and how our actions affect it—is often incomplete. This means that we exercise caution and special concern for natural values in the face of such uncertainty and respect the "precautionary principle" (Racey and Armstrong 1996).

The primary goal of the regional caribou strategy is to stop any further range recession and to maintain occupancy of current woodland caribou range (Ontario Ministry of Natural Resources 1999). The OMNR initiated their work by collecting baseline data on caribou distribution and biology. This information was synthesized and resulted in the recently drafted *Timber Management Guidelines for the Provision of Woodland Caribou Habitat*. These guidelines recommend maintaining a sustainable supply of winter habitat within large tracts of old forest, protecting calving areas, and minimizing human disturbance. Forestry practices were designed to mimic a landscape mosaic that would naturally occur with fire.

The woodland management strategies for caribou are different than they are for moose. They are designed to restore previous landscape structure and composition, whereas moose management strategies deliberately produce forest edge. The habitat management approach developed for caribou is an attempt to sustain a landscape pattern at a scale similar to that created by wildfire. It is believed that this approach will benefit caribou and possibly other forest species that evolved in such an environment. In this regard, caribou have become an indicator of a functioning fire dependent ecosystem.

Communication and consultation with interested parties was a critical part of strategy development. Information was provided to upgrade resource managers' knowledge and to increase the public's awareness of woodland caribou in Ontario. The concept of a caribou management strategy is difficult to understand, so public involvement remains critical. The public, including the forest industry, was consulted about the proposed strategy. The public's response showed a strong dichotomy between environmental and utilitarian values among all the major stakeholder groups. The major issues identified include security of industrial wood supply, quality of the knowledge base, level of awareness of caribou, economic impacts on remote communities, concern about environmental impacts, and silvicultural know-how.

The planners involved in developing the strategy described the need to have an informed and involved public, especially since some of the public perceives that they will be hurt. The planners concluded that one of the biggest problems faced by natural resource managers is trying to trade off utilitarian and environmental concerns pertaining to resource allocation and conservation. It is one of the biggest challenges to “practice, implement, and refine ecosystem-based management in support of sustainable development” (Racey and Armstrong 1996).

Their management must follow a very adaptive process because the new timber management guidelines have not been used before. They are actively monitoring the effect of their habitat manipulations on caribou populations and will make changes as they learn more.

ADDENDUM 7-B
ECOSYSTEM CONSERVATION EXAMPLE - WHITE-TAILED DEER

Ecosystem Conservation Example - White-tailed Deer - Managing an Overabundant Keystone Species

Deer could be considered a "keystone" herbivore. Waller and Alverson (1997) define a keystone species as one that: 1) affects the distribution or abundance of many other species, 2) affects community structure by strongly modifying patterns of relative abundance among competing species, or 3) affects community structure by affecting the abundance of species at multiple trophic levels.

The overabundant deer problem highlights the complexity of the ecosystem's response to changes in the landscape and our attempts to manage those changes over the past 100 years. We recognize the need to manage wildlife communities as part of the ecosystem, not just as a single commodity that is desirable and valuable. If deer is a keystone species, then management programs should consider impacts to other ecosystem components, both plant and animal, and will attempt to improve the health of those components. This is being attempted in Wisconsin under the emerging "Deer Management for 2000 and Beyond" program.

The Wisconsin Department of Natural Resources has prided itself on managing the deer herd in Wisconsin. Hunters have traditionally been the cornerstone of management decisions, but the Natural Resource Board recently recognized there is a more diverse public that is affected by deer management. They set out to give all interests equal representation in developing future guidelines for managing deer. The "Deer Management for 2000 and Beyond" will use public forums to sort issues and actions into a long-range plan that managers will use to keep the herd, habitat, and surrounding communities healthy.

The goals of this planning process are:

- To produce a deer management framework that is flexible, realistic, and meets the needs of other natural resources as well as the desire of a wide range of stakeholders.
- To produce a management plan that will function within the limitations posed by institutional constraints, habitat, social desires, and public safety. Special emphasis will be paid to:

maintaining a healthy herd,
providing opportunities for a variety of diverse user groups,
simplifying and providing consistency in deer management goals and policies,
providing flexibility to adjust management goals when necessary.

A process has been designed for public involvement, from which emerged several issues: forest and ecological damage, private land access, baiting and feeding, sex and age structure of the herd, agricultural damage, herd size and capacity, and believability of population estimates. The planning will continue into the fall of 2000, when decisions will be made regarding implementation.

This program is a good example of sound ecosystem management for several reasons. First, it involves looking at the ecosystem as a whole, including human interaction with deer, as well as deer herd effects on other components of the ecosystem. Second, the public is involved in the planning process. The Department of Natural Resources understands the implications of its decisions on society and the limitations of its authority for deer management. Third, the Department recognizes that it must remain flexible in management actions and learn from its successes and failures (adaptive management). All these components are critical in managing wildlife within the ecosystem.

ADDENDUM 7-C
SCIENTIFIC NAMES OF SPECIES INCLUDED IN TEXT

Plants

Trees

-Ash…..*Fraxinus sp.*
-Aspen (trembling)…..*Populus tremuloides*
-Beech…..*Fagus grandifolia*
-Balsam fir…..*Abies balsamea*
-Basswood…..*Tilia americana*
-Birch…..*Betula sp.*
-Black spruce……*Picea mariana*
-Canada yew…..*Taxus canadensis*
-Hemlock…..*Tsuga canadensis*
-Jack pine…..*Pinus banksiana*
-Red oak…..*Quercus rubra*
-Red pine…..*Pinus resinosa*
-Sugar maple…..*Acer saccharum*
-Tag alder…..*Alnus rugosa*
-White cedar…..*Thuja occidentalis*
-White pine…..*Pinus strobus*
-White spruce…..*Picea glauca*
-Yellow birch…..*Betula alleghaniensis*

Other plants

-Blue beadlily…..*Clintonia borealis*
-Canada mayflower…..*Maianthemum canadense*
-Wild sarsaparilla…..*Aralia nudicaulis*
-Buckthorn…..*Rhamnus sp.*
-Hawthorn…..*Crataegus sp.*
-Purple loosestrife…..*Lythrum salicaria*

Mammals

Ungulates

-Elk…..*Cervus canadensis*
-Moose…..*Alces alces*
-White-tailed deer…..*Odocoileus virginianus*
-Woodland caribou…..*Rangifer tarandus*

Carnivores

-American marten…..*Martes americana*
-Black bear…..*Ursus americanus*
-Bobcat…..*Lynx rufus*
-Canada lynx…..*Lynx canadensis*
-Coyote…..*Canis latrans*
-Fisher…..*Martes pennanti*

-Gray wolf…..*Canis lupus*
-Mink…..*Mustela vison*
-Raccoon…..*Procyon lotor*
-River otter…..*Lutra canadensis*
-Striped skunk…..*Mephitis mephitis*
-Wolverine…..*Gulo gulo*

Hares and Cottontails
-Eastern cottontail…..*Sylvilagus floridanus*
-Snowshoe hare…..*Lepus americanus*

Rodents
-Beaver…..*Castor canadensis*
-Gray squirrel…..*Sciurus carolinensis*
-Porcupine…..*Erethizon dorsatum*
-Vole…..*Microtus sp. and Clethrionomys sp.*

Birds

Loons
-Common loon…..*Gavia immer*

Grebes
-Pied-billed grebe…..*Podilymbus podiceps*

Pelicans and Cormorants
-Double-crested cormorant…..*Phalacrocorax auritus*
-White pelican…..*Pelecanus erthrorhynchos*

Herons
-American bittern…..*Botaurus lentiginosus*
-Black-crowned night heron…..*Nycticorax nycticorax*
-Great egret…..*Ardea alba*

Waterfowl
-American black duck…..*Anas rubripes*
-Blue-winged teal…..*Anas discors*
-Canada goose…..*Branta canadensis*
-Mallard…..*Anas platyrhynchos*
-Wood duck…..*Aix sponsa*

Hawks and Eagles
-American kestrel…..*Falco sparverius*
-Bald eagle…..*Haliaeetus leucocephalus*
-Broad-winged hawk…..*Buteo platypterus*
-Osprey…..*Pandion haliaetus*
-Peregrine falcon…..*Falco peregrinus*
-Red-tailed hawk…..*Buteo jamaicensis*

Grouse
-Ruffed grouse…..*Bonasa umbellus*
-Sharp-tailed grouse…..*Tympanuchus phasianellus*
-Spruce grouse…..*Falcipennis canadensis*

<u>Shorebirds</u>

-American woodcock…..*Scolopax minor*
-Caspian tern…..*Sterna caspia*
-Common snipe…..*Gallinago gallinago*
-Common tern…..*Sterna hirundo*
-Forster's tern…..*Sterna forsteri*
-Herring gull…..*Larus argentatus*
-Piping plover…..*Charadrius melodus*
-Ring-billed gull…..*Larus delawarensis*
-Spotted sandpiper…..*Actitis macularia*
-Upland sandpiper…..*Bartramia longicauda*

<u>Cuckoos</u>

-Black-billed cuckoo…..*Coccyzus erythropthalmus*

<u>Owls</u>

-Barred owl…..*Strix varia*

<u>Woodpeckers and Kingfishers</u>

-Belted kingfisher…..*Ceryle alcyon*
-Downy woodpecker…..*Picoides pubescens*
-Hairy woodpecker…..*Picoides villosus*
-Northern flicker…..*Colaptes auratus*
-Pileated woodpecker…..*Dryocopus pileatus*
-Red-headed woodpecker…..*Melanerpes erythrocephalus*
-Yellow-bellied sapsucker…..*Sphyrapicus varius*

<u>Perching Birds</u>

-American redstart…..*Setophaga ruticilla*
-American robin…..*Turdus migratorius*
-Baltimore oriole…..*Icterus galbula*
-Black-and-white warbler…..*Mniotilta varia*
-Black-capped chickadee…..*Poecile atricapillus*
-Black-throated green warbler…..*Dendroica virens*
-Black-throated blue warbler…..*Dendroica caerulescens*
-Blackburnian warbler…..*Dendroica fusca*
-Blue jay…..*Cyanocitta cristata*
-Brown creeper…..*Certhia americana*
-Brown-headed cowbird…..*Molothrus ater*
-Brown thrasher…..*Toxostoma rufum*
-Chipping sparrow…..*Spizella passerina*
-Common raven…..*Corvus corax*
-Eastern bluebird…..*Sialia sialis*
-Eastern meadowlark…..*Sturnella magna*
-Eastern phoebe…..*Sayornis phoebe*
-Eastern wood-pewee…..*Contopus virens*
-Field sparrow…..*Spizella pusilla*
-Evening grosbeak…..*Coccothraustes vespertinus*
-Grasshopper sparrow…..*Ammodramus savannarum*

-Great crested flycatcher…..*Myiarchus crinitus*
-Hermit thrush…..*Catharus guttatus*
-House wren…..*Troglodytes aedon*
-Indigo bunting…..*Passerina cyanea*
-Kirtland’s warbler…..*Dendroica kirtlandii*
-Least flycatcher…..*Empidonax minimus*
-Le Conte’s sparrow…..*Ammodramus leconteii*
-Marsh wren…..*Cistothorus palustris*
-Northern waterthrush…..*Seiurus noveboracensis*
-Ovenbird…..*Seiurus aurocapillus*
-Pine warbler…..*Dendroica pinus*
-Red-breasted nuthatch…..*Sitta canadensis*
-Red-eyed vireo…..*Vireo olivaceus*
-Ruby-crowned kinglet…..*Regulus calendula*
-Sedge wren…..*Cistothorus platensis*
-Scarlet tanager…..*Piranga olivacea*
-Swainson’s thrush…..*Catharus ustulatus*
-Swamp sparrow…..*Melospiza georgiana*
-Tree swallow…..*Tachycineta bicolor*
-Veery…..*Catharus fuscescens*
-Vesper sparrow…..*Pooecetes gramineus*
-Warbling vireo…..*Vireo gilvus*
-Western meadowlark…..*Sturnella neglecta*
-White-breasted nuthatch…..*Sitta carolinensis*
-Winter wren…..*Troglodytes troglodytes*
-Yellow-rumped warbler…..*Dendroica coronata*
-Yellow-throated vireo…..*Vireo flavifrons*

Amphibians and Reptiles
-American toad…..*Bufo americanus*
-Blanchard’s cricket frog…..*Acris crepitans*
-Blue-spotted salamander…..*Ambystoma laterale*
-Bullfrog…..*Rana catesbeiana*
-Chorus frog…..*Pseudacris triseriata*
-Common garter snake…..*Thamnophis sirtalis*
-Cope’s gray tree frog…..*Hyla chrysoscelis*
-Eastern gray tree frog…..*Hyla versicolor*
-Eastern tiger salamander…..*Ambystoma tigrinum tigrinum*
-Four-toed salamander…..*Hemidactylium scutatum*
-Green frog…..*Rana clamitans*
-Mink frog…..*Rana septentrionalis*
-Mudpuppy…..*Necturus maculosus*
-Northern leopard frog…..*Rana pipiens*
-Northern spring peeper…..*Pseudacris crucifer*

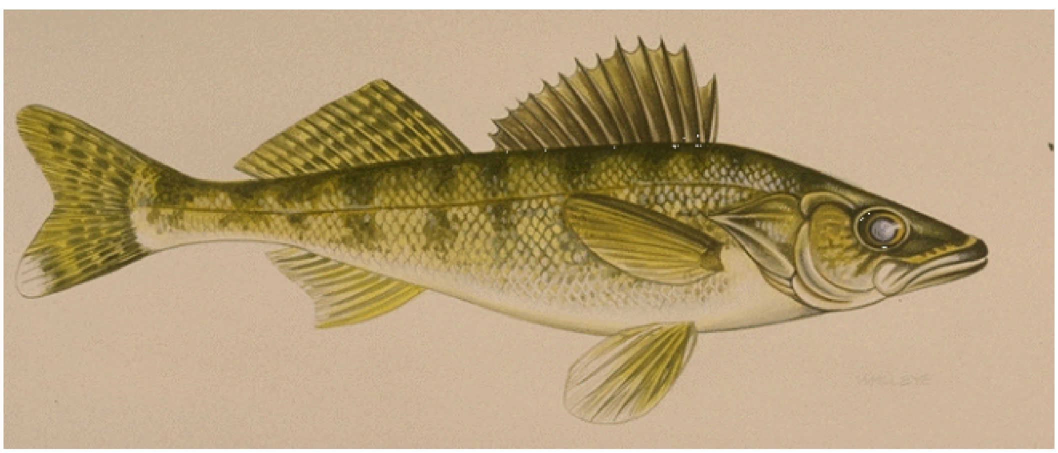
-Painted turtle…..*Chrysemys picta*
-Pickerel frog…..*Rana palustris*
-Redbacked salamander…..*Plethodon cinereus*
-Redbelly snake…..*Storeria occipitomaculata*
-Snapping turtle…..C*heldra serpentina*
-Spotted salamander…..*Ambystoma maculatum*
-Wood frog…..*Rana sylvatica*
-Wood turtle…..*Clemmys insculpta*

Invertebrates
-Deer tick…..*Ixodes dammini*
-Karner's blue butterfly…..*Lycaeides melissa samuelis*
-Rusty crayfish…..*Orconectes resticus*
-Zebra mussel…..*Dreisena polymorpha*

Chapter 8

The Aquatic Communities Progress Report

Insert at beginning of LaMP 2000 Chapter 8.



Walleye Pike
Image provided by Great Lakes Fishery Commission

Lake Superior Lakewide Management Plan
2004

Chapter 8 Contents

Chapter 8
The Aquatic Communities Progress Report

8.0 INTRODUCTION

The Aquatic Communities Committee (ACC) is comprised of fish biologists and aquatic scientists for federal, provincial and state agencies and tribal authorities within the Lake Superior Basin. This committee has a link to the Great Lakes Fishery Commission and its programs through the Lake Superior Technical Committee (LSTC). Many of the ACC members are also members of the LSTC. This unique relationship has meant that through the commitment of both committees to protect, restore and rehabilitate fish populations, habitats and fisheries, common objectives and strategies are shared. The committees have been able to work cooperatively together when seeking support from individual agencies and outside funding sources to help accomplish the requirements of the ACC work plan. This unique relationship has also allowed the committees to respond to some of the challenges and suggested next steps found in the Ecosystem Chapter of the LaMP 2002 Progress report.

The summary of accomplishments described below includes achievements of the 2002-2004 work plan's four priority projects and other lakewide projects. Several of these required data collection from the entire lake or large portions of it. These kinds of projects are expensive and logistically challenging to execute. It was only by forming agency and non-governmental organization partnerships that sufficient resources, expertise, and funding were pooled to do the work. The Canada-Ontario Agreement respecting the Great Lakes Basin Ecosystem (COA) was instrumental in funding the Ontario portion of many of these projects in 2003.

8.1 LaMP ACCOMPLISHMENTS 2002 TO 2004

1. Completed the first of a multiyear hydro acoustic survey that will provide an accurate biomass estimate of pelagic prey fish in Lake Superior as well as provide information that will allow development of a long-term prey fish monitoring survey. *(See details on acoustic surveys below)*

2. Began a multiyear lakewide program to identify and quantify critical habitat for key fish species to develop and understand the linkages between habitat supply and fish community production. *(See details on acoustic surveys below)*

3. Implemented efforts to restore or rehabilitate critical habitat for brook trout and other fish in 14 tributaries around the lake.

4. Broadened the breadth of knowledge and action towards lakewide brook trout rehabilitation through symposia, workshops and multidisciplinary projects,

including population genetics, habitat modeling and assessment, management plan development, population surveys, stocking and protective regulations.

5. Began development of a walleye rehabilitation strategy for Black Bay in western Superior.

6. Established multi-focused, lake-wide sturgeon rehabilitation effort with links to a larger Great Lakes effort through the Great Lakes Fishery Commission (GLFC) publication of a rehabilitation plan for Lake Superior. In addition, funding of Great Lakes workshops, describing the current status of spawning populations in historic sturgeon tributaries, developing a genetic profile for each population and habitat restoration have also helped in the rehabilitation effort.

7. Agencies through the GLFC have developed a list of important research questions related to the Lake Superior aquatic community that seek to improve the understanding of lake trout population sustainability, food web dynamics, native species restoration, lower trophic levels, and the effect of introduced species.

8. Established an inventory of tributary waters crossing along the north shore of Superior to identify existing risks to fish and fish habitat and those crossings in need of remediation. Crossings are prioritized for remedial action based on the level of risk.

9. Begun the process of developing environmental objectives that will support Lake Superior's Fish Community Objectives.

10. Submitted the next State of Lake Superior Report for review and publication by the GLFC (published every 5 years).

11. The International Association for Great Lakes Research held a State of Lake Superior Conference in 2003 at Michigan under the Chairmanship of Dr. Marty Auer, a member of the ACC. This conference focused on lower trophic level studies and knowledge synthesis for the lake.

12. Invasive species accomplishments – agencies continued fish surveillance surveys to document range expansion of ruffe and detect other Aquatic Nuisance Species (ANS) from Thunder Bay, Ontario to Sault Ste. Marie, Michigan. In 2003, round goby and white perch were discovered and confirmed in Thunder Bay Harbour, Ontario. Fish community surveys were continued in the St. Louis River and four other south shore rivers to monitor fish community structure in tributaries colonized by ruffe and other ANS. Educational materials (pocket guides, signage at boat landings, brochures, videos, etc.) continue to be produced by Sea Grant, Federation of Ontario Anglers and Hunters and others. These materials are distributed throughout the Lake Superior basin to prevent the introduction and control the spread of ANS.

13. Partnered with Ontario Power Generation for studies on how to restore sturgeon access to historic spawning sites below Kakabeka Falls on the Kaministiquois River, Thunder Bay.

14. Discontinued stocking of sturgeon in the St. Louis River upon return of adults to historic spawning sites.

15. Continued development of a management plan for brook trout in Wisconsin waters of Lake Superior.

16. Culvert and roadside erosion control video has been developed in Wisconsin. A total of 11 workshops were held throughout the state, 2 in the Lake Superior Basin. A total of 497 government and roadside crew workers participated in workshops, including about 100 in the Lake Superior Basin.

17. A symposium, "Living on the Edge: Protecting Lake Superior's Rivers and Streams", was held to address natural resource considerations in community planning. More than 300 government officials, natural resource personnel, and watershed group members attended.

18. Existing and potential areas of increased non-point pollution in the White, Marengo, and Potato river watersheds, Wisconsin, were documented. Suitable locations to focus stream bank buffer restoration locate retention ponds and create field filter strips were identified and recommended to local governments.

19. A GIS database with multiple Basin-level layers was developed for resource managers to assist decision making related to timber cutting cycles, tree planting programs, master planning, brook trout habitat, CRP and buffers, to best reduce erosion and sedimentation in Lake Superior tributaries.

20. Sea lamprey management and control activities continued in Lake Superior. Progress has been made on alternative control methods such as the use of pheromones to attract spawning-phase sea lamprey.

Selected Accomplishment Details

Using Remote Sensing Techniques to Answer Important Questions about the Aquatic Environment

Fisheries managers around Lake Superior have determined that in order to more effectively manage the Lake Superior fish community, they need to understand the relationship between habitat supply and fish production. Fishery biologists need answers to such questions as the following: Does the amount of spawning habitat limit the number of walleye or lake trout produced annually? Could there be greater numbers of young fish if nursery areas were larger? How many more fish might be produced if connectivity between habitats was improved or critical habitats rehabilitated?

Most of the fish biomass in the lake is produced or resides in water less than 50 m deep**.** This translates into a potential need to map and describe thousands of sq. km of lake and tributary bottom. With recent technological advances, Canadian and American fisheries managers are able to hire experts in acoustic technology to map critical spawning and nursery areas.

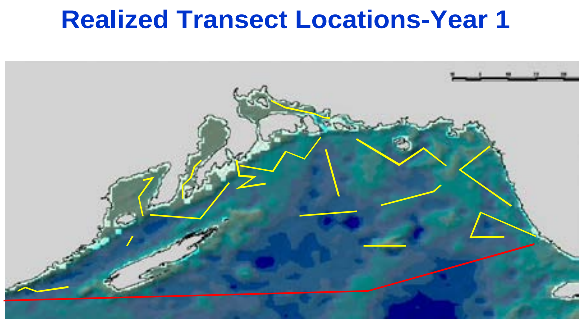
The National Water Research Institute of Environment Canada and the U.S. Geological Survey-Lake Superior Biological Station and others have applied their expertise in acoustic mapping surveys to map the distribution of substrates in specific areas of Lake Superior. Mapped areas include lake trout spawning areas along the Minnesota shoreline, nursery and shallow open water areas of Michipicoten Bay, Ontario, and southern Keweenaw Bay, Michigan, and sea lamprey nursery habitat in Batchawana Bay, Ontario. Other projects in progress or planned include Gull Island Shoal, Wisconsin, Buffalo Reef and Huron Bay, Michigan, Black Bay and Thunder Bay, Ontario.


NWRI survey vessel
Photograph by Susan Greenwood, Ontario Ministry of Natural Resources

By bouncing sound waves off the lake bottom and recording the strength of the return signal, scientists can determine the composition of the substrate. As sound waves are sent and received, location and water depth are simultaneously recorded which allows scientists to create a geo-referenced map of the substrate. The final products of this acoustic mapping procedure are baseline descriptions of current habitat conditions that will support decision-making processes that seek to rehabilitate and sustain near shore fisheries. We now know what substrates (sand, clay, gravel, cobble) are present, in what surficial quantity, at what depth and exactly where they are relative to other substrates or bottom features.

Acoustic technology is also supporting the first ever comprehensive open water prey fish monitoring program for Lake Superior. As partners, the Ontario Ministry of Natural Resources, U.S. Geological Survey Lake Superior Biological Station, Great Lakes Environmental Research Laboratory of the National Oceanographic and Atmospheric Administration, the University of Minnesota-Duluth and member agencies of the GLFC, have developed a lake-wide acoustic assessment program to quantify the abundance of pelagic prey fishes (rainbow smelt, chubs and lake herring) in Lake Superior.


NWRI data collection on site
Photograph by Susan Greenwood, OMNR



R/V Kiyi Year One Transects
Figure by R. Hrabik Univ. of Wisconsin

This project will allow fishery biologists to develop a realistic estimate of the quantity and composition of the prey base in the offshore waters of Lake Superior and address a key piece of the fish community puzzle that has thus far been unavailable to fishery managers. The information gathered will provide valuable insight into the important relationship and balance of predator/prey fish in Lake Superior. Fishery managers will have additional data from which to effectively and adaptively manage Lake Superior fisheries in a stable and sustainable manner.

In 2003 the USGS vessel R/V Kiyi completed work in two of four open water quadrants. Pelagic prey fish abundance and biomass information was collected during night acoustic surveys and mid water trawls conducted in late summer. The methodology, bouncing sound waves off schools of fish swimming at depths of up to 300 m, collected data that through sophisticated modeling and statistical applications provides estimates of fish biomass and density by species.

The program is scheduled to continue into 2006 and will provide the first comprehensive review of just how big the prey fish biomass is, what depths are frequented by what species, and what areas of the lake are the most productive.

Native Species Rehabilitation

In 2003, rehabilitation plans for brook trout, lake sturgeon, and walleye in Lake Superior were completed by multi-agency committees and published by the Great Lakes Fishery Commission. This represents significant progress toward efforts to rehabilitate native fish species in Lake Superior. Plans are available on the web at http://www.GLFC.org.

Nipigon Coaster Brook Trout
Photography by OMNR

<u>Brook Trout Rehabilitation</u>

With the publication of the Rehabilitation Plan for Brook Trout in Lake Superior and continuing and growing emphasis on brook trout rehabilitation, a workshop was held to coordinate and unify coaster brook trout rehabilitation efforts in Lake Superior. Fifty fisheries biologists, fishery managers and other scientists, came together to discuss long-term planning and to begin data consolidation for presentations at the 2004 National Meeting of the American Fisheries Society in Madison, Wisconsin. Participants recognized that some rehabilitation efforts will likely be achieved in 10-20 years while other efforts could take as long as 50-100 years.

Lake Sturgeon Rehabilitation

Progress was made in determining the current population status and abundance of lake sturgeon in historic spawning streams. Since 2002, status assessments have been initiated on eight Canadian tributaries to Lake Superior and one boundary river. They are the Goulais, Chippewa, Batchawana, Michipicoten, White, Little Black, Black, Pic and Pigeon rivers. Assessment netting on these rivers have resulted in the capture and collection of biological data from 70 fish. This effort brings the total number of Lake Superior tributaries in which assessment have been initiated to 15.

In addition to abundance and biological information, progress has been made in the effort to assess the genetic structure of spawning populations. This work seeks to delineate spawning stocks of lake sturgeon in Lake Superior and throughout the Great Lakes basin by their genetic characteristics. Preliminary work has shown that the genetic characteristics being analyzed are well suited to determination of genetic differences and similarities. The project is ongoing and a final report is anticipated in 2005.

Goulais River Sturgeon
Photography by OMNR

Conservation of the genetic integrity of the different spawning populations is an important management consideration. The delineation of management units based on genetic differences will help managers more efficiently target conservation strategies and better understand potential consequences of various management options. Data on levels of gene flow between spawning locations also provide insight into lake sturgeon ecology that is often difficult to detect through traditional population assessments.

8.2 CHALLENGES FOR 2004 TO 2006

Stresses and their impacts on aquatic ecosystems continue to be a challenge in the Lake Superior basin. The ACC has noted a number of challenges that, if successfully addressed, will make significant contributions to the LaMP goals related to the Lake Superior ecosystem and ultimately to human health.

- Establishing agency support for and maintenance of long-term biota and habitat monitoring programs.
- Ensuring the maintenance of healthy aquatic communities on rivers with, and those identified for, hydropower development.
- Completing around-the-lake mapping of near shore fish habitat.
- Preventing invasion and transport of non-native species within the Lake Superior basin.
- Funding continued monitoring efforts for invasive species and fish community changes and status.
- Protecting critical lake and tributary habitats.
- Expanding knowledge of aquatic systems and the human-induced perturbations that may have changed or limited their productivity.

8.3 NEXT STEPS FOR 2004 TO 2006

Future accomplishments will be dependent upon commitments by governments and other organization to support the science, resource management and legislative activities that will protect and restore the basin. During the next reporting cycle, the ACC will continue some projects begun since 2002 and initiate others once needed support has been found.

- Continue with the acoustic projects related to prey fish monitoring and critical shallow water habitat quantification.
- Continue to work with local communities and stakeholders to rehabilitate coaster brook trout, walleye and sturgeon populations.
- Establish environmental objectives for Lake Superior.
- Establish a lower trophic level monitoring program for Lake Superior.
- Report on the status of lake herring since the recovery of its top predator, lake trout.
- Identify inland aquatic systems in need of rehabilitation or protection to meet LaMP objectives. (e.g. stream road crossings with impaired habitat)
- Implement field trials to examine the feasibility of using sea lamprey pheromones as an additional tool for control and management of sea lamprey.

Members of Aquatic Communities Committee

Co-Chairs: Sue Greenwood, Ontario Ministry of Natural Resources
Henry Quinlan, U.S. Fish and Wildlife Service

Members: Mark Ebener, Chippewa-Ottawa Resource Authority
Don Schreiner, Minnesota Department of Natural Resources
Steve Schram, Wisconsin Department of Natural Resources
Owen Gorman, U.S. Geological Survey
Bill Mattes, Great Lakes Indian Fish and Wildlife Commission
Mike Donofrio, Keweenaw Bay Indian Community
Shawn Sitar, Michigan Department of Natural Resources
Mike Fodale, U.S. Fish and Wildlife Service, Sea Lamprey Management
Doug Cuddy, Department of Fisheries and Oceans, Sea Lamprey Management
Tom Pratt, Department of Fisheries and Oceans
Ben Whiting, Grand Portage Band
Tom Doolittle, Bad River Band
Al Rowlinson, Department of Fisheries and Oceans, Fish Habitat Management
Marty Auer, Michigan Technological University
Steve Chong, Ontario Ministry of Natural Resources
Kirsten Cahol, Bad River Band

Chapter 8

The Aquatic Community Part 1: Fish and their Habitat

Attleboro National Fish Hatchery, Atlantic Salmon

Photograph by: William W. Hartley, U.S. Fish and Wildlife Service

Lake Superior Lakewide Management Plan
2000

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EXECUTIVE SUMMARY

The Lake Management Plan written for the aquatic community of Lake Superior is an extension of work conducted by the Lake Superior Committee and Lake Superior Technical Committee (which includes state, provincial, and federal members charged to establish fish community objectives for the Lake Superior basin, under the authority of the Joint Strategic Plan for Management of Great Lakes Fisheries) and provides a necessary link between the Binational Program for Lake Superior and the Great Lakes Fishery Commission. The Aquatic Community LaMP addresses issues primarily related to fish communities of Lake Superior and not lower trophic levels such as plankton, zooplankton, and benthos. The Aquatic Committee of the Lake Superior Work Group is less than one year old and thus did not have enough time to write a fully developed LaMP. The document represented here reflects the best effort by the Committee in the time available.

Aquatic habitat in the Lake Superior basin is classified into five basic types: offshore; nearshore; embayments; tributaries; and inland lakes. Each of these habitats has a specific assemblage of aquatic life that overlap to some extent but by in-large are unique. The offshore habitat makes up roughly 75 percent of the total surface area of Lake Superior and includes all waters deeper than 80 meters. The nearshore habitat is the open water portion of Lake Superior less than 80 meters deep. Embayments are subject to seiche and compose the nearshore areas that are connected to Lake Superior, but exhibit unique physical properties because they are partially protected from the physical dynamics which occur in Lake Superior. Tributaries includes all rivers and streams that empty into Lake Superior and are not subject to seiche. Inland lakes are bodies of water spatially separated from Lake Superior, but located within the drainage basin.

Generally, loss of habitat is an issue only in the tributary, embayment, and inland lake habitats, not the offshore and nearshore habitats. Most of the nearshore and offshore habitat is basically the same as historic times, whereas the vast majority of the embayment, tributary, and inland lake habitat has borne the brunt of habitat destruction. This is not to say that all is completely well with the nearshore and offshore environment for the aquatic community of Lake Superior -- just that these two habitats have few encroachments compared to the other habitats. The offshore and nearshore habitat types of Lake Superior are probably in sufficient quantity and quality to allow achievement of fish community and environmental objectives, but the tributary, embayment, and inland lake habitats do not have sufficient amounts of habitat to allow achievement of fish community or environmental objectives.

The principal stresses to aquatic habitat in Lake Superior include: shoreline development in embayments and inland lakes; hydroelectric facilities; barrier dams; over-exploitation; industrial effluents; mining waste; wetland dredging; atmospheric deposition; agricultural practices; timber harvesting practices; exotic species; potential impacts of sea lamprey control through barriers and

lampricides; Great Lakes shipping; and wetland filling. Atmospheric deposition, exotic species, and sea lamprey control are stresses to the aquatic community which have lake-wide effects, whereas most of the other stresses have more localized effects.

Most of the action plans listed in the Aquatic Community LaMP are intended to gather information on specific aquatic resources rather than to fix problems with the ecosystem. The gathering of basic biological and ecological information must occur first in order to understand the linkages between the aquatic community and habitat. Restoration of the Lake Superior ecosystem can only occur once we understand the linkages between habitat and the aquatic community structure and function. The Aquatic Committee views the lack of information to be as much an impediment to restoring the health of the aquatic community as the actual destruction that has been inflicted on the ecosystem.

Action Plans

Four high-priority action plans for funding are described in this LaMP. The highest priority action plan is to develop a standardized lakewide acoustic monitoring program to evaluate status of the pelagic fish community, costing $739,000 over a four-year time period. The second action plan is to identify and quantify critical habitat for key indicator species by electronically mapping lake bottom substrates and will cost $100,000 annually for an unspecified period of time. The third action plan is to determine the population status and abundance of lake sturgeon in historic spawning streams and to quantify their spawning habitat in these streams. The sturgeon project will cost $60,000 over 3-5 years. The fourth action plan is to add critical and important fish habitat to an existing GIS-based map for Lake Superior. The map project may not have any cost associated with it. Ten other action plans are also identified in the Plan, but few of them have time lines or dollar values associated with them.

A significant advantage of integrating the Lake Superior Committee with the Lake Superior Work Group is that the agencies represented on the Lake Superior Committee have a substantial number of monitoring programs already in place for evaluating aquatic ecosystem health and measuring the response of the aquatic ecosystem to management actions. The management agencies have already committed a substantial amount of money to various research and assessment projects and some of these projects have the long-term commitment necessary for measuring management actions and understanding community dynamics. For each of the principal monitoring projects we describe (1) who is conducting the study, (2) what are the goals and objectives of the study, (3) what general methods are being used, (4) what are some results, (5) who are contact people, and (5) what source document is the primary reference for the study.

Figure 8-1. Action Summary

Project	Lead Agency/ Funding Source	Funded	Needs Funding
Identification of Lake Sturgeon Spawning Habitat	OMNR, Environment Canada, GLIFWC, U.S. EPA CEM	X	
Juvenile Lake Sturgeon Habitat Requirements	USFWS, U. S. Dept. of Interior, GLIFWC, BRNRD	X	
Rehabilitation of Lake Sturgeon	RCFD, GLNPO, BRNRD, USFWS, U.S. Dept. of Interior	X	
Rehabilitation of Brook Trout	USFWS/USGS, U. S. Dept. of Interior, MI DNR, Trout Unlimited, National Park Service, and RCFD	X	
Rehabilitation of Lake Trout	MN DNR, Federal Aid for Sport Fish Restoration, WI DNR, WI funding from sale of trout and salmon stamps, MI DNR, OMNR, Provincial, RCFD, U.S. Dept. of Interior , COTFMA, KBIC	X	
Lake Trout Model Development	COTFMA/GLFC, GLFC Coordination Funds, USFWS Restoration Act, OMNR, UW-Stevens Point	X	
Ruffe and Native Fish Surveillance	USFWS/USGS-BRD and U. S. Dept. of Interior	X	
GIS Based Maps of Fish Habitat	Habitat Committee and U.S. EPA CEM	X	
Acoustics Project	GLERL/USGS-BRD and USFWS Restoration Act		X
Creel Survey at Isle Royale	MI DNR and unknown		X
Habitat Mapping	MI DNR/USGS-BRD and unknown		X
Nursery Habitats of Juvenile Lake Sturgeon	Michigan Tech Univ., GLFC, USFWS Restoration Act		X
Analysis of Plankton Samples	USGS-BRD and unknown		X

Figure 8-1. Action Summary

Project	Lead Agency/ Funding Source	Funded	Needs Funding
Caloric Density of Predators & Prey	OMNR and USFWS Restoration Act		X
Implementation of Deepwater Trawling	USGS-BRD and Dept. of Interior		X
Measuring Fish Community Productivity	GLERL/USGS-BRD and unknown		X
Implementation of Fish Community Monitoring	USGS-BRD, COTFMA, Dept. of Interior, USFWS, MI DNR, MN DNR, WI DNR, KBIC, OMNR, unknown		X
Stream Improvement Projects	Army Corps of Engineers and unknown		X
Autopsy-Based Health Profiles	USFWS and unknown		X
Appropriate Flows from Hydroelectric Facilities	State agencies and unknown		X
Brook Trout and Trout and Salmon Competition	Trout Unlimited and unknown		X

8.0 ABOUT THIS CHAPTER

Coordinated, inter-jurisdictional management of the Great Lakes fishery was facilitated by the 1955 Convention on Great Lakes Fisheries between the governments of Canada and the United States which created the Great Lakes Fishery Commission. The bilateral agreement affirmed the need for the two countries to collaborate on the protection and perpetuation of Great Lakes fish resources. The Great Lakes Fishery Commission was charged to formulate and coordinate research programs to enhance the sustained productivity of the Great Lakes, to recommend appropriate measures for enhancing the Great Lakes, to implement a sea lamprey control program, and to publish scientific and other information regarding the Great Lakes and its fishery.

The Great Lakes Fishery Commission provides the forum in which fishery agencies from each of the Great Lakes can interact and develop strategies for jointly managing resources of common concern. In 1981, a Joint Strategic Plan for Management of Great Lakes Fisheries was signed by state, federal, and provincial management agencies with jurisdiction on the Great Lakes (Great Lakes Fishery Commission 1994). The Joint Strategic Plan affirmed commitments among the various Great Lakes agencies to work together and expressed their commitment to cooperation, consensus, and strategic thinking.

Lake committees made up of state, provincial, and two inter-tribal fishery agencies are the action arm of the Joint Strategic Plan. Each lake committee is made up of one representative from each agency, with a technical committee to investigate specific fishery issues. The Lake Superior Committee is composed of representatives from the Departments of Natural Resources in Michigan, Minnesota, and Wisconsin, Ontario Ministry of Natural Resources, Great Lakes Indian Fish and Wildlife Commission, and Chippewa/Ottawa Treaty Fishery Management Authority. The Lake Superior Committee develops common Fish Community Objectives (Busiahn 1990), appropriate stocking levels, harvest targets, law enforcement capabilities, and management plans. The 1990 Fish Community Objectives for Lake Superior are currently being rewritten by the Lake Superior Committee in part to link the objectives to habitat conditions in Lake Superior and to accommodate the Binational Program for Lake Superior.

The Lake Superior Technical Committee provides the Lake Superior Committee with scientific and technical information, and is composed of representatives from the same agencies as the lake committee, as well as individuals from the U. S. Fish and Wildlife Service, Canadian Department of Fisheries and Oceans, and U. S. Geological Survey-Biological Resources Division (BRD). The Technical Committee regularly develops lakewide strategies for sampling fish populations in Lake Superior and coordinates efforts to describe the status of the Lake Superior fish community. The technical committee has written a lakewide plan for rehabilitating populations of lake trout (Hansen 1996) and a report describing the state of the Lake Superior fish community in 1992 (Hansen 1994). Subcommittees of the Technical Committee have written documents describing the status of brook trout, lake sturgeon, and walleye in Lake Superior, and have developed rehabilitation plans for each of these species (Newman and others 1999a).

In March of 1999, the Lake Superior Technical Committee was charged to serve as the link between the Lake Superior Committee and the Binational Program for Lake Superior. In that capacity, the Technical Committee chair also serves as the co-chair of the Lake Superior Work Group Aquatic Committee. The linkage of the Lake Superior Work Group and Lake Superior Committee was a logical decision since it was the lake and technical committees which have been working cooperatively to describe and manage the future fish community of Lake Superior.

Development of this Aquatic Community chapter is an extension of the work of the Lake Superior Committee and its Technical Committee completed over the last two decades. The Aquatic Committee used many of the documents created by the Lake Superior Committee and Lake Superior Technical Committee to develop this chapter. These documents include Fish Community Objectives (Busiahn 1990); the new draft of Fish Community Objectives; the rehabilitation plans for lake trout (Hansen 1996), brook trout (Newman and others 1999a), lake sturgeon, and walleye; the 1992 state of Lake Superior report (Hansen 1994); and a discussion paper on development of fish community objectives written by the Technical Committee in March 1998.

This Aquatic Community chapter does not deal with lower trophic levels in Lake Superior. Since the Lake Superior Technical Committee primarily deals with issues relating to fish, the Lake Superior Technical Committee has little information to describe phytoplankton, zooplankton, and benthos in Lake Superior. In addition, because the Aquatic Committee was formed less than a year ago, we have had little time to bring individuals with the knowledge of the lower trophic levels into the realm of the Committee and the Lake Superior Work Group.

8.1 IDENTIFICATION OF CRITICAL AND IMPORTANT HABITAT AREAS

Within the Lake Superior basin, there are both critical and important habitats defined at the species scale. The Aquatic Committee defines "critical habitat" as that which is essential for spawning and reproduction. "Important habitat" is defined as areas where juvenile and adult forms live and feed when not spawning. Critical and important habitats can occur in the same geographic area for a certain species or be separated by substantial distances. Critical and important habitats for several fish species indigenous to Lake Superior are described in Addendum 8-A.

Critical and important fish habitat is classified into five basic types in Lake Superior, each with a specific assemblage of fish species. The fish community of each habitat type overlaps to some extent, and indigenous species like lake trout, and burbot, and non-indigenous species like Pacific salmon and sea lamprey are found in each habitat type at some point in their lives. However, the fish community of each habitat type is fairly unique. The habitat types are as follows:

- **Offshore --** the open water portion of Lake Superior deeper than 80 meters which makes up over 75 percent of the total area of the lake.
- **Nearshore --** the open water portion of Lake Superior less than 80 meters deep.

- **Embayments** -- comprised of the nearshore areas that are connected to Lake Superior, but exhibit unique physical properties because they are partially protected from the physical dynamics which occur in Lake Superior. Embayments can be natural or man-made and include coastal wetlands, bays, harbors, and estuaries that are subject to lake seiche.
- **Tributaries --** all rivers and streams in the watershed that empty into Lake Superior and are not subject to seiche.
- **Inland lakes --** bodies of water spatially separated from Lake Superior, but located within the drainage basin.

The offshore area makes up the largest share of habitat in Lake Superior and contains nearly all the important and critical habitat for siscowets, humpers, chubs, and deepwater sculpin. Siscowets and humpers are actually different forms of lake trout that are found only in Lake Superior (Rahrer 1965, Burnham-Curtis and Bronte 1996). The offshore habitat of Lake Superior is comprised of about 6.3 million hectares (ha) of surface water. The fish community of the offshore habitat is relatively simple and composed of pelagic adult lean lake trout, siscowets, humpers, burbot, Pacific salmon, sea lamprey, deepwater ciscoes, lake herring, and deepwater sculpins.

The nearshore habitat is comprised of approximately 1.9 million ha of surface water. Most of the important and critical habitat for lean lake trout, lake herring, and lake whitefish is found in the nearshore habitat (Figure 8-2). The nearshore habitat has a greater assemblage of fish species than the offshore habitat and the fish community of the nearshore habitat is composed mainly of lean lake trout, siscowets, burbot, Pacific salmon, lake herring, lake whitefish, round whitefish, rainbow smelt, ninespine sticklebacks, trout-perch, pigmy whitefish, and longnose and white suckers.

Fish communities living in the embayment habitat are more complex than in the offshore and nearshore habitats because Lake Superior’s embayments are warmer, more productive, and more physically diverse than the remainder of the lake. Fish living in the embayments include many of the same fish that live in the nearshore habitat, but also warm and cool water fish species such as walleye, smallmouth bass, yellow perch, rock bass, northern pike, lake sturgeon, johnny darters, emerald shiners, longnose dace, sand shiners, bullheads, and carp.

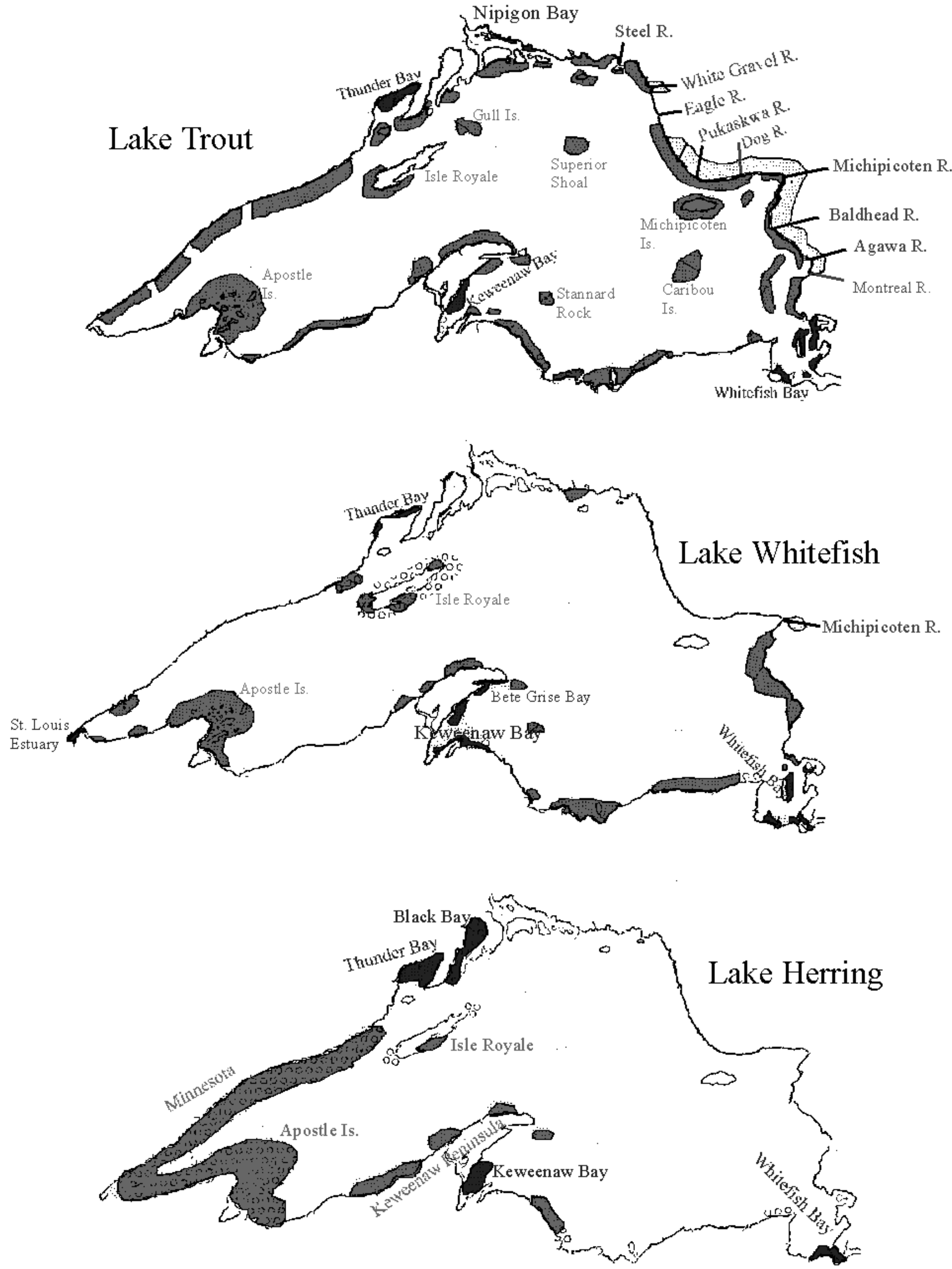

Figure 8-2. Distribution of known spawning habitat for lake trout, lake whitefish, and lake herring in Lake Superior

from Goodyear and others (1981), Coberly and Horrall (1980), and Goodier (1981)

There are over 3,300 kilometers (km) of tributaries available to Lake Superior fish. Many fish that live in the embayment, nearshore, and offshore habitat types spend part of their life in tributaries, but the fish community of tributaries includes brook trout, burbot, lake sturgeon, longnose and white suckers, redhorse suckers, Pacific salmon juveniles, mottled sculpin, bullheads, the many species of minnows, and sea lamprey. Tributaries are the critical habitat for nearly all of the species listed above. Rainbow trout and brook trout are found in more tributaries of Lake Superior than the other major fish species, while lake trout and lake whitefish are found in the fewest number of tributaries. The number of tributaries known to contain important fish species in Lake Superior is described below based on creel surveys, some published literature (Moore and Braem, 1965), and personal communications with area managers and biologists.

Table 8-1 Lake Superior Tributaries Containing Fish Species

Fish species	Minnesota	Wisconsin	Michigan	Ontario	Total
Lake trout	0	0	3	2	5
Lake sturgeon	2	3	2	6	13
Pink salmon	10	8	65	7	90
Brown trout	2	76	29	?	107
Chinook salmon	6	15	27	14	62
Coho salmon	8	59	56	8	131
Walleye	2	9	29	40	80
Brook trout	52	90	93	19	254
Rainbow trout	65	74	112	19	270

There are many inland lakes within the Lake Superior basin that exhibit a wide range of habitat conditions and contain a variety of fish communities. Habitats in these lakes vary from small, shallow winter-kill lakes to deep, cold-water lakes, and as a result of the morphometry of the lakes, fish assemblages vary from warm water to cold-water fish communities. The morphology and water chemistry of the inland lakes are dictated by the geology of the Lake Superior basin that includes Canadian Shield, sandstone, and sandy-loam shoals. Lake Nipigon is the largest of the inland lakes within the Lake Superior basin and is a significant source of the water that flows into Lake Superior.

8.1.1 Lake Superior Resources and Their Stresses

Two types of fish communities are found in Lake Superior: those that are not limited by habitat and those that are. Habitat limits can be thermal, spatial, and artificially imposed by man due to some form of degradation or manipulation to the habitat. Species that are not limited by habitat and for which there is a sufficient amount of habitat to sustain and achieve both fish community and environmental objectives include:

- All lake trout forms, lake herring, lake whitefish, chubs, and round whitefish that spawn in Lake Superior itself;
- Salmonines other than lake trout that live in the offshore, nearshore, and embayment habitat; and
- Prey species like sculpins, trout-perch, ninespine stickleback, and pigmy whitefish.

In comparison, the following fish species are limited by habitat in the Lake Superior basin and achievement of fish community or environmental objectives may not be possible under current habitat conditions.

- Lake trout stocks that spawn in rivers found in eastern Ontario waters of the lake. The Montreal River population of lake trout may be limited by habitat due to fluctuating water levels caused by a hydroelectric facility.
- The lake whitefish stock that historically spawned in the St. Louis estuary -- this stock of whitefish was extirpated over 100 years ago because of habitat destruction.
- Walleyes, lake sturgeon, Pacific salmon, brown trout, coaster brook trout, and other fish that live in Lake Superior but spawn in the tributaries, as well as tributary resident species such as brook trout, brown trout, sculpins, and cyprinids -- logging, road crossings, beaver and man-made dams, are causing (1) loss of spawning and nursery habitat (due to sedimentation) and (2) unfavorable changes in the thermal habitat.
- Yellow perch, northern pike, and smallmouth bass. These species are limited thermally, limited by depth, and limited by habitat quantity in Lake Superior.

Generally, habitat loss causes impairments in the tributary, embayment, and inland lake habitats. Most of the nearshore and offshore habitat has remained unchanged, whereas the vast majority of the embayment tributary, and inland lake habitat has borne the brunt of habitat destruction. The offshore and nearshore habitat types of Lake Superior are probably in sufficient quantity and quality to allow achievement of fish community and environmental objectives, but the tributary and embayment habitats do not have sufficient amounts of habitat remaining to allow achievement of fish community objectives for species like lake sturgeon, walleye, and brook trout.

The principal stresses to aquatic habitat in Lake Superior include:

- shoreline development in embayments and inland lakes,
- hydroelectric facilities,
- barrier dams,
- over-exploitation,
- industrial effluents,
- mining waste,
- wetland dredging,
- atmospheric deposition,
- agricultural practices,
- timber harvesting practices,

- exotic species,
- potential impacts of sea lamprey control through barriers,
- Great Lakes shipping, and
- wetland filling.

Atmospheric deposition, exotic species, and sea lamprey control practices are stresses to the aquatic community which have lakewide effects, whereas most of the other stresses have more localized effects.

The principal stresses found in each of the habitat types are as follows:

- **Offshore** -- atmospheric deposition, dumping or discharges from vessels, and exotic species.
- **Nearshore** -- atmospheric deposition, dumping or discharges from vessels, industrial effluents, exotic species, over-exploitation, and mining.
- **Embayment** -- petroleum emissions and spills, atmospheric deposition, industrial effluents, dumping or discharges from vessels, exotic species, over-exploitation, loss of wetlands, land-use practices, atmospheric deposition, urban development, sedimentation, and shoreline development.
- **Tributary** -- industrial effluents, hydroelectric facilities, barrier dams, loss of wetlands, land-use practices, exotic species, timber harvesting, mining, agricultural practices, urban development, and sedimentation.
- **Inland Lakes** -- Shoreline development, timber harvest, agriculture, contamination through septic systems or runoff, mining, atmospheric deposition, urban development, sedimentation, industrial effluents, loss of wetlands, and hydroelectric dams.

The effect of the various stresses on the aquatic community is easy to recognize. Overfishing is partly responsible for the demise of deepwater ciscoes (Lawrie and Rahrer 1973), brook trout (Newman and Dubois 1997), lake sturgeon (Slade and Auer 1997), walleye (Hoff 1996), lake trout (Hansen and others 1995a), and lake herring (Selgeby 1982) in Lake Superior from the late 1800s to the mid 1900s. Also during the same time period hydroelectric development and man-made barriers on tributaries, sedimentation of tributaries due to poor logging and land use practices, and physical destruction of stream channels contributed to the demise of brook trout, walleye, lake sturgeon, and lake trout (Lawrie and Rahrer 1973, Slade and Auer 1997, Hoff 1996, Newman and Dubois 1997). Predation by exotic sea lampreys contributed to the collapse of lake trout and whitefish populations in Lake Superior from the 1940s through the 1960s (Jensen 1976, Pycha 1980, Smith and Tibbles 1980, Coble and others 1990, Hansen and others 1995a). Logging, road crossings, and beaver and man-made dams are currently causing loss of spawning and nursery habitat in tributaries due to sedimentation and unfavorable changes in the thermal habitat. Walleye populations in Lake Superior are affected by high mercury levels, paper mill effluent, and habitat loss (Schram and others 1991).

Overfishing, hydroelectric development, logging practices, and sea lampreys are all stresses that can and are being managed. Overfishing is currently being prevented through fishery management regulations developed separately or jointly by state, provincial, and tribal agencies (Legault and others 1978, Ebener 1997, Brown and others 1999). Overfishing is currently not a pervasive problem on Lake Superior and occurs only in isolated areas on a few fish species, such as lake trout in Whitefish Bay and eastern Ontario waters. Re-licensing of hydroelectric facilities on U.S. tributaries through the Federal Energy Regulatory Commission has resulted in changing water power management from peak operations to run-of-the-river flows which are more friendly to aquatic life and fish reproduction. More stable flow regimes implemented on the Nipigon River in the 1990s have helped increase reproduction of brook trout. Present day logging practices can be regulated to protect aquatic life. These practices are much less stressful to aquatic life than historic methods. Sea lamprey populations have been successfully suppressed throughout most of Lake Superior because of integrated control using chemicals, barrier dams, and sterile-male releases.

Other stresses to the aquatic community of Lake Superior are much less easy to recognize or manage. It appears that chemical contaminants in fish flesh have not limited the ability of Lake Superior fish to reproduce, although it is uncertain if reproduction would be better if the chemical contaminants were in lower concentrations or absent. Some of the chemicals being deposited in Lake Superior through atmospheric deposition originate outside of the Lake Superior basin, including outside North America, making it impossible to address management of these chemicals in the Aquatic Community LaMP. The presence of chlordane in siscowet trout from Lake Superior is an example of a chemical that originates outside the Lake Superior basin, yet the chemical is in sufficient quantity in siscowets that consumption advisories have been issued by the state of Michigan. Michigan closed its state-licensed commercial fishery for siscowets in the early 1990s due to chlordane contamination of the fish. In addition, shoreline development on inland lakes typically results in the loss of aquatic vegetation which is important to survival and reproduction of some fish species, such as yellow perch and northern pike, however, the direct, measurable effects of shoreline development are not as recognizable. Land use practices and urban development alter drainage patterns and increase surface water run-off, but the effects on the aquatic community are difficult to assess and understand.

The effect of exotic species other than sea lampreys on the aquatic community remain unknown and exotic species are difficult to manage. Rainbow smelt have provided valuable commercial and sport fisheries on Lake Superior since the 1930s, and have been the primary food source for many of the predatory fish in Lake Superior (Legault and other 1978, Conner and others 1993). Conversely, when rainbow smelt enter a Great Lake, indigenous fish such as lake herring and whitefish initially decline in abundance, although there has been no direct measure of the effect of smelt on these fish species in Lake Superior (Selgeby and others 1994a). A negative effect of the Eurasian ruffe on the Lake Superior fish community has not currently been found, although ruffe have become the most abundant fish species in the estuaries of some tributaries to western U.S. waters of Lake Superior (Hoff and others 1998). Pacific salmon also provide valuable sport and limited commercial fisheries on Lake Superior, but they may also negatively interact with indigenous brook trout in some tributaries (Newman and others 1999a). Implementing changes in the stocking rates of hatchery-reared Pacific salmon typically causes substantial political problems for fishery agencies, and since most Pacific salmon now living in Lake Superior are the product of natural reproduction, there are few options available for managing their populations. The exotic zooplankton *Bythotrephes* is very abundant in early summer in Lake Superior and fish regularly eat *Bythotrephes*. However, the effect of *Bythotrephe* on the aquatic community is unknown. The use of chemicals and barrier dams to control sea lamprey, although good at protecting lake trout and whitefish, present a difficult balancing act to managers because these control tools also have potential negative effects on lake sturgeon migration up tributaries and survival of recently hatched lake sturgeon in tributaries. Sea lamprey continue to kill a substantial number of lake trout in Lake Superior every year (Hansen and others 1994, Weeks 1997).

8.1.2 Inland Lake Aquatic Resources and Their Stresses

This discussion is organized by state and province.

Minnesota

Minnesota's portion of the Lake Superior watershed contains many inland lakes. These areas are extremely important for both recreation and tourism. Much of the aquatic resource in Minnesota is in very good condition. High quality pristine areas in the watershed include portions of the Boundary Waters Canoe Area, natural heritage lake trout lakes that are supported only by wild populations, state parks, and state and federal forests.

The Minnesota watershed, however, is in general and in a few specific areas experiencing increased stress from a variety of sources. The major stresses include logging, iron ore mining, increased construction of roadways, increased development of both riparian stream and lake shoreline areas, and increased exploitation on the fisheries resource. There are ongoing discussions with the timber industry on implementation of best management practices, specifically requiring increased protection of the riparian zone along streams, lakes, and wetlands. The Minnesota Division of Forestry is presently working on a new policy for timber harvest in the Lake Superior watershed. Iron ore mining is an important industry in northeast Minnesota and in general has made efforts to improve water quality near mining sites, but there are still areas that need attention. With the renewed interest in experiencing "wilderness" and the changing demographics of our society there is a major development boom in Minnesota's portion of the Lake Superior watershed that includes expansion of roads, businesses, cabins/homes, and general shoreline development.

Lake trout, in the natural heritage lakes, and other native species are especially affected by the above stresses because of their need for undisturbed shoreline and native aquatic vegetation for natural reproduction. Many of the other stresses in the watershed are being addressed through a variety of policy and regulatory changes. The Binational Program will provide an important tool to assist in implementing the required changes.

Wisconsin

The soft water seepage lakes are most commonly found in the Wisconsin Lake Superior basin. These lakes are typically clear, slightly acid, and relatively infertile. The principal fishery resources pursued by anglers in the Wisconsin basin include muskellunge, northern pike, walleye, largemouth and smallmouth bass, and panfish.

Lakes within the Wisconsin Lake Superior basin are continually being stressed as an increasing number of people purchase shoreline properties. Shoreline development has resulted in a reduction of aquatic habitat and in some cases a reduction in water quality. Management actions to improve water quality include acquisition of remaining undeveloped shoreline near fish spawning areas and wildlife marshes, and improvement in sewage treatment facilities.

Michigan

The MI DNR, U.S. Forest Service, U.S. Fish and Wildlife Service, Bay Mills Indian Community, and Keweenaw Bay Indian Community have assessed many of the 200 to 300 lakes in the Lake Superior drainage of Michigan. Most of these lakes support a cold or cool water fishery. The cold-water lakes have brook trout or rainbow trout as the dominant predator, while the cool-water lakes have walleye, northern pike, or perch as the dominant predator. A few lakes are characterized as warm-water and have a largemouth bass/bluegill fish community. A compliment of various prey species also exists in these lakes, dominated by minnows (cyprinids) and suckers (catostomids).

In general, Michigan inland lakes within the Lake Superior basin receive minimal fishing pressure because of the sparse human population in their region, and their remote locations. A few lakes are storage reservoirs used for hydroelectric power; associated lake level fluctuations negatively impact those fisheries. These lakes include: Gogebic, Prickett, Bond Falls, Victoria, Silver, McClure, and Autrain.

The Michigan Department of Environmental Quality and the Great Lakes Indian Fish and Wildlife Commission have instituted a general mercury advisory for fish existing within all lakes, stipulating that smaller and leaner fish should be eaten. Specific advisories exist for the following lakes: Siskiwit, Gogebic, Bond Falls Flowage, Perch, Langford, Clearwater, Lindsley, Marion, Torch, Portage, Parent, Lake Independence, Cisco Chain, Deer, and Autrain. All of the above lakes have fish advisories for mercury, while Portage, Siskiwit, and Torch lakes also have advisories related to PCB contamination.

Currently, there are two Areas of Concern (AOCs) identified by the International Joint Commission within Michigan's Lake Superior basin: Torch Lake in Houghton County and Deer Lake in Marquette County. In the Torch Lake AOC, the impaired beneficial uses identified include restrictions on fish and wildlife consumption, fish tumors or other deformities, and degradation of benthos. With a review currently in process, this list is undergoing significant revision. For instance, sauger, the fish species most heavily afflicted with tumors and anomalous growths, is no longer present within the AOC. Consequently, the Fish Consumption Advisory was lifted in 1989. In 1998, however, PCBs were detected in samples, and a Fish Consumption Advisory was reinstated for women and children. Deer Lake environmental concerns include elevated mercury levels in fish. The Michigan Department of Environmental Quality has been working to address and remediate these concerns for several years. Their efforts have been supported by the Deer Lake PAC since 1997. The AOC includes the Carp River watershed, Deer Lake, and the Carp River downstream about twenty miles to Lake Superior in Marquette.

Ontario

Ontario's portion of the Lake Superior watershed contains numerous inland lakes supporting lake trout, brook trout, walleye, and northern pike fisheries. Some of the lakes, particularly in the Thunder Bay and Sault Ste. Marie areas, are experiencing stress due to the effects of shoreline development. However, the majority of the lakes are undeveloped and the shorelines are managed as public lands. Current Ontario government policy prohibits development on lake trout lakes where all of the shoreline is public land, and limits development on patent lands on lake trout lakes based on the late summer hypolimnetic dissolved oxygen level.

More widespread stresses to Ontario inland lakes are associated with logging activity and exploitation. Ontario's Timber Management Guidelines for the Protection of Fish Habitat have been used since 1988 to minimize the effects of crown land logging operations on inland lakes and streams. A large, ongoing research project was initiated in 1990 to experimentally evaluate the effects of logging on boreal forest lakes and streams. The results of this project will help in the development of more scientifically-based guidelines to ensure the protection of fish habitat. With regard to exploitation on Ontario's inland lakes, standardized rapid assessment protocols have been developed in order to identify stressed populations which may require management intervention and to facilitate the development of management support models. These protocols include the spring littoral index netting, fall walleye index netting, and nearshore community index netting. A modified version of the trap net, based nearshore community index netting, has recently been used to assess walleye populations in the Georgian Bay area of Lake Huron and may prove to be a valuable assessment tool for the assessment of sensitive populations in embayments on Lake Superior.

Lake Nipigon is the largest inland lake in Ontario's portion of the Lake Superior watershed; with a surface area of 448,060 ha it is approximately one quarter the size of Lake Ontario. Lake Nipigon supports trophy sports fisheries for brook trout and lake trout as well as commercial fisheries for whitefish, lake trout, walleye, and more recently rainbow smelt. Stresses acting on the fish community of Lake Nipigon include exploitation, water level fluctuations, and the introduction of the non-indigenous rainbow smelt. Declines in Lake Nipigon walleye stocks in the early 1980s, attributed primarily to over-fishing, have led to angling closures and reduced commercial walleye quotas. Recovery of the walleye stocks in Ombabika Bay is being monitored on an ongoing basis. Rainbow smelt were first discovered in Lake Nipigon in the early 1980s and smelt numbers have increased dramatically since. It is unknown, however, what the long-term impacts of smelt will be on the Lake Nipigon fish community.

The level of Lake Nipigon is controlled by hydroelectric dams on the Nipigon River and by the diversion of water from the Ogoki River into Ombabika Bay. Winter draw-downs have impacted brook trout reproduction by de-watering brook trout spawning shoals. The past impact on other fall spawning species is unknown. A recent water level agreement on the Nipigon system is expected to reduce water level impacts on Lake Nipigon as well as on the Nipigon River.

The Lake Nipigon Fisheries Assessment Unit (LNFAU) was established by the Ontario Ministry of Natural Resources around 1980 in order to establish long term data sets on the Lake Nipigon fish community. Current LNFAU projects include fish community index netting, fall walleye index netting, commercial catch sampling, smelt index netting, and lake trout index netting. More recently the Kitchi-gaa-ming Field Fisheries Unit of the Anishnawbec/Ontario Fisheries Resource Center (A/OFRC) has also been conducting fisheries assessment work on Lake Nipigon. The Lake Nipigon Fish Community Index Netting project is currently undertaken as a partnership between LNFAU and A/OFRC.

8.1.3 Tributaries and Their Stresses

Minnesota

Minnesota tributaries to Lake Superior are generally very harsh environments for salmonine fish to inhabit in comparison to tributaries in other jurisdictions. Nearly all Minnesota tributaries have natural barriers a short distance upstream from Lake Superior. These barriers limit movement of anadromous fish within tributaries and reduce juvenile salmonine habitat. Minnesota tributaries have very little groundwater intrusion and stream flows are controlled mainly by precipitation. The largest Minnesota tributary to Lake Superior is the St. Louis River, which forms the boundary between Minnesota and Wisconsin. The St. Louis River is an AOC and progress is being made to alleviate stresses to the river. Some major stressor concerns and their related species include lake sturgeon in the St. Louis River, anadromous species such as brook trout, and wild Pacific salmon in all tributary streams.

Wisconsin

Wisconsin has many high quality, spring-fed trout streams which provide extensive recreational fishing opportunities. Some streams have small coastal estuaries, which provide habitat for fish and wildlife species. Most tributaries were impacted by a complete forest cut-over in the middle 1800s, extensive fires, and the cumulative watershed damage caused by man’s activities (e.g. agriculture). Resulting higher peak flood flows increased channel water velocities, which displaced the remaining woody cover, eroded stream banks, straightened channels and ultimately sorted bottom substrates. Although watershed health has generally improved, the channel damage caused during this time period is still not healed. Management actions include land acquisition, beaver control, stream habitat improvement in critical areas, and fishery regulations.

Michigan

According to an unpublished U. S. Fish and Wildlife Service Sea Lamprey Control stream database, there are 420 Michigan tributaries to Lake Superior. These include the Montreal River, a boundary stream shared with Wisconsin. Most of these streams are small, having a discharge less than 0.5 m^3/sec. The discharge depends mostly on surface runoff. These surface-runoff streams typically experience wide fluctuations in physical and chemical parameters. In Big Garlic River in Marquette County, Michigan, discharge ranged from 0.3 to 3.3 m^3/sec.

Discharge rates are even higher during spring runoff. During these periods, temperatures ranged from 0 to 21^{o} C, conductivity ranged from 40 to 124 micro-mhos, total alkalinity ranged from 14 to 62 ppm, and total hardness ranged from 20 to 66 ppm (Zimmerman 1968). Eighty-one of the 420 streams in the database did not have a name, likely because they were extremely small and had intermittent discharge. These fluctuations in stream parameters influence the fish community in a number of ways. Increased discharge in the spring due to melting snow and rain provides improved access to tributaries by spring-spawning anadromous species such as rainbow trout and suckers. However, stream resident fish and juveniles of anadromous fish that require an extended nursery period are adversely affected by the fluctuating conditions. Reduced discharge and temperature extremes during summer, fall, and winter reduce available habitat (e.g. anchor ice) and lead to increased mortality in the tributary and the lake. Shrinking habitat forces anadromous juveniles to migrate into Lake Superior at less than optimum size and age.

Ontario

Ontario tributaries to Lake Superior support a diverse group of fisheries including walleye, northern pike, rainbow trout, coho and chinook salmon, lake trout, lake sturgeon and brook trout. Stresses to Ontario tributaries include hydroelectric development and shoreline development. Hydroelectric development has impacted a number of Lake Superior tributary watersheds including the Kaministiquia, Nipigon, Pic, Michipicoten and Dog rivers. A water management agreement was developed in 1990s for the Nipigon watershed which balances the needs of all stakeholders on the Nipigon River and Lake Nipigon with the protection of fish habitat. This agreement is expected to serve as a model for other tributaries in Ontario with hydroelectric development as hydroelectric leases are re-negotiated.

Shoreline development has impacted fish habitat in tributaries in localized areas such as Thunder Bay and Sault Ste. Marie, Ontario. More widespread stresses are associated with water crossings. Both the trans-Canada highway and railway are close to the north shore of Lake Superior and cross the majority of tributaries. Many of the crossings are sub-standard by current standards and have resulted in barriers to migration of anadromous fish, habitat fragmentation and severe erosion problems in some cases. Improvements to some of these crossings have been undertaken as opportunities have arisen. Tail-water controls have been used to improve fish passage at perched or inclined culverts. Flood conditions frequently cause washouts and replacement culverts are sized and installed to facilitate fish passage. Recently the Ontario Ministry of Natural Resources has taken a proactive role in ensuring that natural channel design and ‘soft’ engineering approaches are used in the design of replacement water crossings. It is anticipated that this approach will reduce the frequency of washouts as well as facilitating fish passage.

A standardized stream assessment protocol has been developed by the Ontario Ministry of Natural Resources in order to evaluate and compare stream habitats and the status of fish populations in the streams. Using this method, efforts are ongoing to establish a database of baseline habitat and population information on Lake Superior tributary streams in order to identify streams in need of harvest controls or habitat rehabilitation. In addition, the standardized assessment protocol will facilitate monitoring of the effects of such management actions.

8.1.4 Embayments and Their Stresses

Besides the tributaries to Lake Superior, a substantial amount of habitat destruction has taken place in the embayment habitat. Most of the AOCs on Lake Superior are located in embayments, particularly in Canada. The AOCs in the embayment habitat of Canada are located in Nipigon Bay, Jackfish Bay, Thunder Bay, and Peninsula Harbour.

Nipigon Bay is the most northerly area of Lake Superior and receives most of its drainage from a watershed underlain by the Canadian Shield. Environmental concerns in Nipigon Bay center around water quality issues, degraded fish populations, and impaired natural watercourses. In 1995, the Nipigon AOC completed remedial strategies for ecosystem restoration, most of which have been implemented. Actions taken include reducing water level fluctuations, completion of secondary treatment at the Norampac Inc. paper mill, and cleanup and rehabilitation of nearshore and tributary habitat. All actions associated with rehabilitation of native brook trout, walleye and lake trout stocks in the Nipigon AOC have been implemented or completed. A reference for this AOC is the Nipigon Bay Remedial Action Plan, Stage 2: Remedial Strategies for Ecosystem Restoration (1995).

The Jackfish Bay AOC is located on the north shore of Lake Superior, approximately 250 km northeast of Thunder Bay, ON. The AOC consists of a 14 km stretch of Blackbird Creek between the Kimberly-Clark pulp mill and Jackfish Bay including Lake ‘A’, Moberly Lake, and Jackfish Bay. The town of Terrace Bay is the closest community west of the AOC. Jackfish Bay and Blackbird Creek have been impacted by effluent from the pulp and paper industry, resulting in contaminated sediments and degradation of fish and wildlife habitat. Process changes and the installation of secondary treatment at the Kimberly-Clark mill have substantially improved effluent quality, resulting in environmental improvements. It is expected that previously deposited organic sediments will degrade over time and the Remedial Action Plan recommends natural recovery as the preferred option in the 1998 Stage 2 report on remedial strategies for ecosystem restoration. Natural rehabilitation of aquatic communities will continue to be monitored in the Jackfish AOC. A reference on this AOC is the Jackfish Bay Remedial Action Plan, Stage 2: Remedial Strategies for Ecosystem Restoration (1998).

The Thunder Bay AOC fans out from the city of Thunder Bay, ON, extending for about 28 km along the shoreline and up to nine km offshore. The AOC occupies the southwest corner of Thunder Bay proper. The greatest impacts on the area have resulted from industrial and urban development along the Thunder Bay waterfront and adjoining tributaries. Dredging, waste disposal, channelization, and the release of a number of pollutants have eliminated a significant portion of quality habitat along the waterfront. The consequences have included a loss of species abundance and diversity, reduced recreational opportunities, and a decline in the aesthetic value of the area. Impacts resulting form the release of process effluent into the Kaministiquia River and Lake Superior have been significantly reduced in recent years because of improved effluent treatment and changes in industrial processes; however, the ecosystem remains impaired in a number of ways. Some areas support benthic communities reflective of organic enrichment, contaminated sediments, and habitat loss from dredging activities. Dredging restrictions are still in effect because of sediment contamination in the harbour, particularly health hazards for water based recreational activities. A reference for this AOC is the Thunder Bay Remedial Action Plan, Stage 2: Remedial Strategies for Ecosystem Restoration (1999).

Peninsula Harbour is located on the northeastern shore of Lake Superior approximately 290 km east of the city of Thunder Bay, ON. The AOC is roughly bounded by the watershed of the harbour and Pebble Beach, and extends outward approximately 4 km from the Peninsula in to Lake Superior. The area has problems associated with degraded fish and benthic communities and high levels of toxic contaminants in fish and bottom sediments. The preferred remediation option currently under consideration is to remove mercury contaminated sediments and isolate them in a Confined Disposal Facility. Mercury levels in lake trout have stabilized at a mean value of 0.35 mg/kg from 1984 to 1996 and are not significantly different from lake trout sampled at other locations along the north shore of Lake Superior. A reference for this AOC is the Peninsula Harbour Remedial Action Plan, Stage 2: Remedial Strategies for Ecosystem Restoration (1999).

8.2 ACTION PLANS

Most of the action plans listed in the Aquatic Community LaMP are intended to gather information on specific aquatic resources rather than fix problems with the ecosystem. The gathering of basic biological and ecological information must occur first in order to understand the linkages between the aquatic community and habitat. Restoration of the Lake Superior ecosystem can only occur once we understand the linkages between habitat and the aquatic community structure and function. The Aquatic Committee views the lack of information to be as much an impediment to restoring the health of the aquatic community as the actual destruction that has been inflicted on the ecosystem. Kelso and Hartig (1995) described various projects and methods being implemented in the Great Lakes basin to modify habitat to benefit the ecosystem. They stated that these projects would provide the foundation for selecting and evaluating habitat modification and conservation actions. Unfortunately, many of those projects were either incomplete or had not been started by 1995. As a result, they provide little assistance with development of strategies for restoring the aquatic ecosystem of Lake Superior.

Nearly all of the action plans and strategies described below are based on the fish community objectives (Busiahn 1990), rehabilitation plans for lake trout (Hansen 1996), brook trout (Newman and others 1999a), walleye, and lake sturgeon, and the state of the lake report for Lake Superior (Hansen 1994). All of these plans were written by either the Lake Superior Technical Committee and its subcommittees or the Lake Superior Committee itself. The first four of the action plans, or projects, have been given the highest priority for funding by the Aquatic Committee. These projects are aimed at increasing our knowledge of predator-prey interactions and linking fish community dynamics to habitat.

8.2.1 Acoustics Project

The goal of this project is to develop a standardized lakewide monitoring program to evaluate the status of the pelagic fish community of Lake Superior. Objectives of the project are as follows:

1. To develop species-specific acoustic size-length relationships for pelagic prey fishes in Lake Superior.
2. To quantify species-specific spatial distribution patterns with respect to environmental conditions such as water temperature, bathymetric depth, water column depth, etc.
3. To develop statistical models for remote species identification of fishes with estimates of variance using information from objectives 1 and 2 and from trawling.
4. To develop and implement a sampling design to quantify and assess pelagic prey fish abundance and biomass.
5. To attempt to develop a correction factor for observed differences in the species-species abundance and biomass estimates between traditional bottom trawls and acoustic surveys.

The product of this work will be a strategy for conducting long-term acoustic work to estimate the biomass of the pelagic fish community of Lake Superior.

Acoustics sampling involves sending an electronic signal down through the water column of a lake from a vessel as that vessel moves along a straight line transect. The strength and shape of the returning signal to the vessel can be used to estimate fish species composition in the water column and the size of the fish. The Lake Superior Technical Committee and Lake Superior Work Group have developed indicators for the offshore and nearshore aquatic communities that include trends in abundance of key aquatic species like lake herring, exotic species, and predators to meet both ecosystem and fishery management objectives. Acoustic sampling must play an important role in estimating and monitoring the abundance of these key aquatic organisms.

The acoustics project will cost $739,00 (U.S.) and will be divided into two projects. The first is a 2-year project that addresses objectives 1 through 3 above at a cost of $139,000 (U.S.). The second project is a 4-year study that addresses objectives 4 and 5 above at a cost of $600,000 (U.S.).

8.2.2 Habitat Mapping

The goal of this project is to identify and quantify critical habitat for key fish species that are both indicators of ecosystem health and fish community stability. This project involves using remote sensing and advanced global positioning systems to describe the distribution and quantity of Lake Superior bottom substrates. Surveys would be conducted in areas that are critical to reproduction and rearing of fish indigenous to Lake Superior, such as lake trout, especially in areas where habitat has been destroyed or altered. These surveys should include those areas that are not already protected. The current draft of fish community objectives for Lake Superior and the Binational Program both call for quantification of fish habitat and identification of its distribution within the lake. Important lake trout spawning habitat has already been mapped in portions of Minnesota waters of Lake Superior. Whitefish spawning habitat has also been mapped in lower Whitefish Bay. We expect this project to cost about $100,000 annually and to last until all of the important areas have been mapped.

8.2.3 Rehabilitation of Lake Sturgeon

The goal of this project is to determine the current population status and abundance of lake sturgeon in historic spawning streams and to quantify sturgeon spawning habitat in those streams. Lake sturgeon were historically very abundant in the nearshore and tributary habitats of Lake Superior, but a combination of habitat destruction, hydroelectric development, and over-fishing resulted in the lakewide collapse of the populations early in the twentieth century. The current lake sturgeon rehabilitation plan gives this work high priority for future research. This project will cost about $20,000 per stream per year, with at least two streams per year being studied. These costs include personnel and radio tagging equipment. This project could last for 3 to 5 years.

8.2.4 GIS-Based Maps of Fish Habitat

This project involves adding data on fish habitat to the existing Habitat Committee project to develop Geographic Information System (GIS)-based maps of habitat in the Lake Superior basin. These data would include the attributes associated with each stream listed in the Lake Superior Technical Committee Discussion Paper. The goal would be to visualize fish habitat in Lake Superior by identifying, quantifying, and illustrating that habitat on GIS maps. The cost of this project is unknown and will be based upon the ease of incorporating the information into the existing databases.

8.3 OTHER ACTION PLANS

Besides the four high-priority action plans listed above, there are many more projects identified by the Aquatic Committee that need to be funded. These projects were identified by either the Aquatic Committee or were recommended in the lake trout, brook trout, lake sturgeon, and walleye rehabilitation plans. These projects are listed below in no particular order of priority. They have no time-lines and only a few of the projects have a suggested annual budget.

1. Describe the nursery habitats, habitat requirements, and seasonal distribution of juvenile lake sturgeon in tributaries to Lake Superior where sturgeon are currently known to spawn.
2. Measure fish community productivity in tributaries and measure the contribution of tributaries to both fish production and productivity of Lake Superior; $50,000 (U.S.) annually.
3. Implement bottom trawling to waters greater than 300 feet deep in Lake Superior; $25,000 (U.S.) annually.
4. Implement fish community monitoring in tributaries, embayments, and nearshore habitat less than 45 feet deep to gather background data prior to invasion of new exotic species to Lake Superior; $75,000 (U.S.) annually.
5. Analyze U. S. Geological Survey - BRD plankton collections made around Lake Superior over the last decade; $25,000 (U.S.) annually.

6. Conduct stream improvement projects to reduce sand loading on brook trout streams; $40,000 (U.S.) annually per stream.
7. Determine the usefulness of autopsy-based health and condition profiles for juvenile lake trout.
8. Determine the caloric densities of predators and their prey throughout the water column of Lake Superior for use in bioenergetics models; $50,000 (U.S.) annually for three years.
9. Determine the appropriate spring flows that enhance recruitment of brook trout, walleye, and lake sturgeon on tributaries with hydroelectric facilities.
10. Measure the competitive relationship between coaster brook trout and naturalized anadromous salmonines and their hybrids in spawning and nursery habitats, and in Lake Superior.

8.4 MONITORING PROGRAMS

A significant advantage of integrating the Lake Superior Committee with the Lake Superior Work Group is that the agencies represented on the Lake Committee have a substantial number of monitoring programs already in place for evaluating aquatic ecosystem health and measuring the response of the aquatic ecosystem to management actions. The management agencies have already committed a significant amount of money into various research and assessment projects. Some of these projects have the long-term commitment necessary for measuring management actions and understanding community dynamics. For each of the principal monitoring projects we describe the following (if available): (1) who is conducting the study; (2) what are the goals and objectives of the study; (3) what general methods are being used; (4) what are some results; (5) who are the contact people; and (6) what is the primary reference for the study. These monitoring projects are organized by the five basic habitat types in Lake Superior.

8.4.1 Offshore Habitat

Deepwater predator surveys - This is a cooperative project developed by the Lake Superior Technical Committee and implemented by nearly every agency with representation on, or involvement with, the committee. Preliminary bioenergetics analyses conducted in western Lake Superior in the early 1990s indicated that siscowets dominated the predator fish population in that portion of the lake (M. Ebener, COTFMA, personal communication). To confirm this and determine if a similar domination occurred lakewide, member agencies of the Lake Superior Technical Committee conducted a lakewide assessment in June 1996 and August-September 1997 to determine the relative abundance and biology of predator fish, especially siscowets, at depth strata from inshore as shallow as 60 feet to offshore depths that at some stations exceeded 600 feet.

Graded-mesh gill nets were fished overnight on the bottom at 60-foot depth intervals in 1996 and at 120-foot depth intervals in 1997. The nets were 6 feet deep and 2,700 feet long and were made up of 300-foot panels of 2.0-, 2.5-, 3.0-, 3.5-, 4.0-, 4.5-, 5.0-, 5.5-, and 6.0-inch extension-measure multifilament nylon or monofilament mesh. Fish captured in each mesh in each net were identified, measured, weighed, sex and maturity determined, number and stage of sea lamprey attack marks recorded, and scales or otoliths collected for age analysis. Otoliths were collected from all siscowets, burbot, and leans 23 inches and longer, and scales collected from leans less than 23 inches and all other fishes. Fin clips were recorded for all salmonines and stomachs were collected from all salmonines and burbot for diet analysis.

This assessment will be repeated in 2000 or expanded by member agencies in future years, but the time frame between sampling years has not yet been determined. These data have not yet been published. The contact persons for the deepwater predator survey are listed below.

Don Schreiner	Minnesota Department of Natural Resources (MN DNR)
Stephen Schram	Wisconsin Department of Natural Resources (WI DNR)
Owen Gorman	U. S. Geological Survey - BRD
Mike Gallinat	Red Cliff Fisheries Department
William Mattes	Great Lakes Indian Fish and Wildlife Commission
Michael Donofrio	Keweenaw Bay Indian Community
Shawn Sitar	Michigan Department of Natural Resources (MI DNR)
Mark Ebener	Chippewa/Ottawa Treaty Fishery Management Authority
Bryan Henderson	Ontario Ministry of Natural Resources

8.4.2 Nearshore Habitat

Fish Community Surveys - The U.S. Geological Survey- BRD has conducted surveys of fish populations and communities in U.S. and Canadian waters of the lake. The objective of this continuing assessment study is to provide annual estimates of recruitment, relative abundance, biomass, age structure, and size structure of important prey fishes such as lake herring, rainbow smelt, slimy sculpin, spoonhead sculpin, deepwater sculpin, and ninespine stickleback. Species such as lake herring, rainbow smelt, slimy sculpin, spoonhead sculpin, deepwater sculpin, and ninespine stickleback are ecologically important because they are common prey for lake trout and other salmonines (Conner and others 1993, Selgeby and others 1994b). Lake herring, rainbow smelt, slimy sculpin, spoonhead sculpin, deepwater sculpin, nine-spine stickleback, and other prey species require annual monitoring because they are short-lived and experience large annual variations in abundance. In these surveys, bottom trawls with a 11.7-m headrope and 12.7-mm stretched mesh cod end are towed at a speed of 4.3 km/h across contours beginning at 15 m and ending after reaching the maximum depth obtainable within 1 hour. These surveys were conducted annually in the spring at 43 to 53 locations in U.S. waters during 1978 to 1999, and at 33 to 35 locations in Ontario waters during 1988 to 1999.

The annual surveys showed that recruitment, which was measured at age 1, varied by a factor of 3,000 for lake herring. In contrast, recruitment of rainbow smelt varied by a factor of only 4 in recent years, and most other species showed similar variations in recruitment. In decreasing order, lake herring, lake whitefish, rainbow smelt, ninespine stickleback, trout-perch, and slimy sculpin composed most of the biomass in U.S. waters. In recent years, biomass was greater than the long-term mean for lake whitefish, and lower than the mean for trout-perch, rainbow smelt, lake herring, slimy sculpin, and ninespine stickleback. Prey abundance and biomass data are being used along with other data to model energy flow through the ecosystem. Those models have resulted in predictions of population changes after management strategies are implemented. The primary contacts for the fish community survey are Owen Gorman or Michael Hoff of the U.S. Geological Survey- BRD in Ashland, Wisconsin. The primary reference for this study can be found in Selgeby and others (1994b) and Hoff and Bronte (1998).

Spring lake trout assessment fishery - An annual spring assessment was initiated in Michigan and Wisconsin waters in 1959 to assess lean lake trout relative abundance, contribution of hatchery lake trout, sea lamprey wounding, and various lean lake trout biological parameters (Pycha and King 1975). Spring surveys are now conducted annually from mid-April through early June throughout the U. S. and Canadian waters of Lake Superior within the nearshore habitat. The goal of the assessment fishery is to monitor the abundance of wild and hatchery lean lake trout for the purpose of understanding both the dynamics of the populations and the potential impacts of lamprey and fishing activities on the populations. Specific objectives are to gather biological and relative abundance data from most of the stocks in Lake Superior. Minnesota began the assessment fishery in the mid 1960s, while in Ontario, the assessment fishery did not begin until 1997.

Nylon multifilament or monofilament gill nets of 4 ½ inch stretched mesh, 210/2 twine diameter, and 1.8 meters high are used to capture lake trout for the study. Nets are set in roughly the same sample location every year depending upon the agency conducting the survey in waters of 60 to 240 feet deep and lifted after three nights. Total length and weight are determined for each fish, and each fish is examined for the presence of fin clips and sea lamprey marks. Stomach samples are collected from 100 lean and 100 siscowet lake trout in each management unit. A scale or otolith is taken from the fish in order to determine age. The total number of wild and hatchery lean lake trout is recorded for each gang of nets lifted.

The results from this study serve many purposes. Biological and relative abundance information is used to develop models of lake trout populations for predicting total allowable catches, impacts of sea lamprey control actions, and fishery management actions. The relative abundance data have been used to evaluate fish community goals for lake trout in Lake Superior and to evaluate progress towards lake trout rehabilitation. The long-term relative abundance data can be used to measure the health of the Lake Superior nearshore habitat for the Binational Program on Lake Superior.

The primary contacts for the spring lake trout assessment fishery are:

Don Schreiner	Minnesota Department of Natural Resources (MN DNR)
Stephen Schram	Wisconsin Department of Natural Resources (WI DNR)
Shawn Sitar	Michigan Department of Natural Resources (MI DNR)
Mike Gallinat	Red Cliff Fisheries Department
Michael Donofrio	Keweenaw Bay Indian Community
Mike Petzold	Ontario Ministry of Natural Resources

Ken Gebhardt	Bay Mills Indian Community
Mark Ebener	Chippewa/Ottawa Treaty Fishery Management Authority

The results of this study can be found in Pycha and King (1975), Peck and Schorfhaar (1991 and 1994), Hansen and others (1995a), and Hansen and others (1995b).

Summer lake trout gill net survey - Lake trout less than 17 inches long are not common in the sport harvest and generally are not legal in the commercial harvest. Thus, they are considered pre-recruits to these fisheries. Knowledge of the status of these pre-recruit fish would provide some insights regarding management of these fish when they recruit to fishable size in future years. The status of pre-recruit lean and siscowet lake trout less than 17 inches total length are assessed throughout U.S. waters of Lake Superior from Grand Portage, Minnesota to Grand Marais, Michigan. This study has been ongoing since 1970 and is conducted every year.

Multifilament nylon or monofilament graded-mesh gill net of 1.5 to 3.5-inch stretch-measure mesh in ¼ or ½ inch increments are used to capture pre-recruit lake trout. Gangs of these nets are fished on the bottom overnight for approximately 24 hours at depths of 90 to 250 feet from late July through August each year. Data recorded for each fish captured in each mesh size in each gill net gang includes species and total length for all fish; a structure for aging is collected from each lean and siscowet lake trout, other salmonines, burbot, and subsamples of coregonines, along with corresponding fin clip, sea lamprey marks, sex, and maturity data. Otoliths are the structure taken from all siscowets and leans larger than 23 inches long and scales are taken from all other species sampled. Stomachs are collected from a subsample of leans and siscowets in each management area.

Contact persons for the summer lake trout gill net survey are:

Shawn Sitar	MI DNR
Don Schreiner	MN DNR
Stephen Schram	WI DNR
Mike Gallinat	Red Cliff Fisheries Department

Results of this assessment have been documented in Peck and Schorfhaar (1991 and 1994).

Diet Summaries - The objective of this study is to provide long-term trend information on the food eaten by predatory fish in Lake Superior. This is a cooperative effort that began in 1992 and involves all members and agencies that participate on the Lake Superior Technical Committee. Stomachs are collected from all predatory fish, but primarily lean and siscowet lake trout, caught during routine spring lake trout assessment surveys throughout the U. S. and Canadian nearshore waters of Lake Superior. The objective is to collect stomachs from 20 lean and 20 siscowet trout each season in each of the following size classes: < 200 mm, 200-399 mm, 400-599 mm, 600-799 mm, and > 800 mm.

Stomachs are removed intact, placed in individually marked plastic bags, and typically frozen for later analysis. Stomachs are dissected and food items removed, categorized, enumerated, and weighed. Fish identified during dissection are placed in one of the following food categories: rainbow smelt, coregonines, (*Coregonus* spp.), burbot, sculpins (*Cottus* sp.), sticklebacks, salmonines (trout and salmon), other fish, *Mysis*, amphipods, and terrestrial insects. Data are described as percent weight composition and percent frequency of occurrence by season, spatial unit, and size class of predator.

Data analysis has revealed that rainbow smelt are the principal dietary supplement for lean lake trout in the spring. The agencies have also determined that siscowet lake trout have a more diverse diet than lean lake trout and coregonines compose a higher percentage of the siscowet diet.

The primary contact for this project is Chuck Bronte of the U. S. Geological Survey - BRD. The primary literature reference for this project is Conner and others (1993).

Angler Creel Surveys - The Michigan, Wisconsin, and Minnesota Departments of Natural Resources, and Ontario Ministry of Natural Resources conduct on-site direct-contact angler creel surveys in portions of Lake Superior to estimate angler harvests. In Michigan, the survey is conducted at specific ports every year from Black River Harbor to Munising. Minnesota divides its shoreline into two areas and creates two clusters of sample sites in each area where clerks contact sport anglers. These surveys estimate angling effort in hours fished and harvest in number of each species caught and kept. Survey clerks collect various biological data from a sample of harvested fish. An angler survey was conducted in Lake Superior waters of Isle Royale in 1998 through a cooperative effort by Isle Royale National Park, MI DNR, Grand Portage Band of Chippewa, and Keweenaw Bay Indian Community. This survey estimated effort and harvest, but also estimated the number caught and released. In 1990, charter boat fisheries operating in Michigan waters were required to provide the MI DNR with reports of sportfish harvest for each month fished. Michigan began their survey in 1984, while other agencies have been conducting creel surveys for somewhat longer than Michigan.

Contact persons for the angler creel surveys are Don Schreiner of the MN DNR, Stephen Schram of the WI DNR, and Gerald Rakoczy of the MI DNR. Results of these surveys are in Peck (1992), Lockwood and others (1999).

Lake trout spawning substrate study - An inter-agency project to electronically map and describe the bottom substrates in Minnesota waters of Lake Superior that may be important as lake trout spawning sites was completed in 1999. Acoustics signals were used to identify and classify habitat on the lake bottom along most of the Minnesota shoreline of Lake Superior at depths less than 100 feet. Funding for the study came from LTV Steel Company.

Survey data were collected with an echosounder, RoxAnn signal processor, global positioning system, and computer. Transects of 200 ft. wide were made perpendicular and parallel to shore. A statistical technique was developed to place precise statistical boundaries around the signals that were returned from the lake bottom to the RoxAnn. The equipment allowed the researchers to produce estimates of the amount of very good, good, and poor lake trout spawning habitat based on depth and amount of large rocky substrate.

The contacts for information from this study are Dr. Carl Richards of Minnesota Sea Grant in Duluth, Minnesota and Don Schreiner of the MN DNR. Results of the study have been published and can be found in Richard and others (1999). A series of digital and hard maps of bottom substrates and their quantity is available on CD-ROM.

Lake Trout Population Models - In 1998, the Lake Superior Technical Committee began a process to develop a lake-wide lake trout population model for Lake Superior. Various agencies and individuals in the Lake Superior basin were involved in development of models of lake trout populations, and while the tasks by themselves were useful, they were also isolated. The Technical Committee sought to coordinate these separate tasks to produce a management tool that could be applied throughout Lake Superior. This tool would also be valuable to managers and the Great Lakes Fishery Commission. The goal of the modeling task is to evaluate fish community objectives, sea lamprey control, and sustainability of the fish community on a lake-wide basis.

The task involves inviting technical staff from all management agencies and researchers in current modeling tasks to a series of workshops over three to five years. In addition to the workshops, the Technical Committee is soliciting the efforts of various researchers and helping them apply for grants to aid in development of the model. As of January 2000, there are three ongoing research projects that will be used to help build the population model. One project involves evaluating compensatory growth mechanisms in lake trout in Lake Superior. Another project will evaluate the appropriate spatial scales for modeling lake trout in Lake Superior and will assist with data consolidation. The last project involves constructing stock assessment models and a projection model for evaluating management strategies.

The primary contact for this project is Mark Ebener of the Chippewa/Ottawa Treaty Fishery Management Authority. No results have been published from this project, but a document titled "Minutes from the Lake Trout Model Development Workshop, Workshop 1 - Scoping Session" is available from Mark Ebener or Gavin Christie of the Great Lakes Fishery Commission.

KITES - National Science Foundation, Sea Grant, and University of Minnesota at Duluth have funded a project titled "**K**eweenaw **I**nterdisciplinary **T**ransport **E**xperiment in Lake **S**uperior." This goal of the project is to understand how storms influence biological, geological, and chemical material and biota along the Keweenaw Peninsula, and how the Keweenaw current produces differences in composition and productivity of nearshore and offshore plankton communities. A coastal jet exists along the west shore of the Keweenaw Peninsula, producing water speeds of up to 7 cm per second along the peninsula. The Ontonagon River empties into the current with the result that the river contributes 25 percent of all river-borne sediments to U.S. waters of Lake Superior. The KITES project has 13 researchers involved from seven agencies assessing three major study sites located along the west side of the peninsula. Data are being collected from buoy moorings, boats, and satellite images. Sampling started in May of 1998.

The primary contact for this study is Dr. Elise Ralph of the University of Minnesota, Duluth, Minnesota. No results have been published from this study.

8.4.3 Embayments

Chequamegon Bay Fish Community Survey - It is important to monitor the status and trends of populations of walleye, yellow perch, and other species in the embayments of Lake Superior because those areas have sustained the greatest amount of environmental damage (Lake Superior Work Group 1995). The structure and stability of the summer fish communities of Chequamegon Bay, Wisconsin have been studied and analyzed from data collected during 1973-1996 with bottom trawls at 39 stations. The study continues to be conducted annually.

Fish were sampled annually from mid-July to early August by taking one 10-minute bottom trawl tow at each station. The locations of the stations were permanently established in the first year and were sampled by randomly selecting coordinates within ten, 1.83-m depth strata. The proportion of stations in each stratum was equal to the proportion of the stratum area to that of the bay.

Fifty-three fish species were collected during the study, but relative abundance of 20 species described most of the internal variability of the data for all species. Abundance data for the 20 species showed that two communities existed in the bay; one inhabited shallow water up to 3.0 m deep while the other inhabited water greater than 3.0 m deep. The deep-water community, whose variation was best described by eight species, underwent three periods of change in abundance: 1973 to 1978, 1979 to 1988, and 1989 to 1996. In contrast, the shallow-water community was stable through the 24 years studied. Dynamics of the deep-water community were greatly affected by changes in stocking rates of lake trout and splake, and by rehabilitation of lake herring and lake whitefish populations. Information on the existence, structure, stability, and habitats used by fish communities in the bay will be useful for assessing changes in those communities that result from further changes in the bay or lake ecosystems.

The primary contact for this study is Michael Hoff of the U. S. Geological Survey - BRD. The primary literature for this study is Hoff and Bronte (1999).

Lake Sturgeon Surveys - Lake sturgeon are assessed each year in Chequamegon Bay, Wisconsin, using large mesh gill nets. Information on movements, age, growth, and relative abundance is used to develop effective management strategies. A stocking program in the St. Louis River is being evaluated by sampling during the spring lake trout survey and the summer graded mesh assessment in Lake Superior itself.

The primary contact for this survey is Stephen Schram of the WI DNR. A scientific publication of interest is Schram and others (1999).

Upper St. Mary's Fish Community Survey - In 1991, the Chippewa/Ottawa Treaty Fishery Management Authority initiated a series of surveys in the upper St. Mary's River area of

Whitefish Bay with the goal of establishing a walleye fishery and determining management strategies for harvesting walleye from the area. The primary objectives of the study are to monitor trends in abundance of the fish community, to collect biological information from selected species, to determine population characteristics of selected species, and to evaluate the walleye stocking program. Walleye fry, spring fingerlings, and fall fingerlings have been stocked in the area every year since 1989. The study and walleye stocking have been conducted annually through 1999.

Drop nets, beach seines, bottom trawls, and electrofishing gear are used to capture fish for the study. Drop nets are fished in Waishkey Bay during early July to monitor abundance of adult yellow perch, walleye, northern pike, pumpkinseed, rock bass, smallmouth bass, bullheads species, redhorse suckers, and white suckers. Day- and night-time beach seines are used to capture and assess age-0 and age-1 walleye and whitefish abundance, as well as the abundance of the fish community in the littoral area from May through early October. Bottom trawls are made at randomly selected sites using either a 16-foot otter trawl or a 4-foot beam trawl from May through September. Two ten minute trawl tows are made perpendicular to shore in waters of 10 to 60 feet deep at each site, and the total number and weight of each species caught are recorded for each trawl tow. Night-time electrofishing surveys are conducted during mid-September of each year to assess abundance of age-0 walleyes and monitor abundance of other important fish species. Biological data are collected from all walleyes, yellow perch, northern pike, smallmouth bass, and trout and salmon caught during all surveys, and the number of each fish species caught in each survey are also recorded.

The primary contacts for the study are Ken Gebhardt of the Bay Mills Indian Community and Mark Ebener of the Chippewa/Ottawa Treaty Fishery Management Authority. No scientific publications have been written from the study, but annual reports summarizing the study are available from Ken Gebhardt or Mark Ebener.

8.4.4 Tributaries

Abundance of Anadromous Adults - The number of anadromous adult salmonids ascending several tributaries are estimated by the MN DNR and WI DNR. Anadromous adult salmonids ascending the French River in Minnesota are captured in a weir, while the number of adult salmonids are counted at the observation window at the Brule River, Wisconsin, sea lamprey barrier/fishway. The window on the Brule River fishway allows salmonids to be measured and identified to species prior to moving upstream.

The primary contacts for this study are Don Schreiner of the MN DNR and Stephen Schram of the WI DNR. A publication of interest on this study is Schreiner (1995).

McIntyre River Rainbow Trout Population Assessment - The goal of this is study is to better understand rainbow trout population dynamics in the McIntyre River and to determine the status of an individual stock of rainbow trout in a heavily exploited system. The specific objective is to monitor total numbers of adult rainbow trout migrating upstream to spawn. The study began in 1999 and is ongoing.

In May 1999, a resistivity fish counter (Aquatic Ltd, Logie Counter 2100C) was installed at the upper end of the fish ladder at Lake Tamblyn on the McIntyre River. This device detects the passage of fish across an array of three electrodes. When a fish passes over the three electrodes, a change in resistance occurs because the fish is more conductive than the water it displaces. This change of resistance is recorded and analyzed by the counter using a firmwave algorithm to determine if it fits a typical fish pattern. Should the counter assess that a fish has passed over the array based on this comparison, the time, direction of travel and peak signal size of the fish event is recorded and stored for downloading and analysis.

Data from the April to June 1999 migration period indicates that a total of 414 fish were assessed to have passed over the counter in an upstream direction. Of these, 53% were correctly assigned as upstream migrants, while 47% were recorded as events with “trace signature” subsequently proven to be fish generated events. Peak migration of 115 fish (28% of total run) occurred on May 1, 1999. Current data suggests a population that may be dominated by spawners in the 2-4 lb. classes with fewer than 11% of the run being composed of fish greater than 5 lb.

The primary contact for this study is Ken Cullis of the Ontario Ministry of Natural Resources. A reference for this study is report summarizing the 1999 results that is available from Mr. Cullis.

Juvenile Lake Sturgeon Studies on the Bad River - The Bad River, Wisconsin, is one of only two U.S. tributaries to Lake Superior that support a self-sustaining population of lake sturgeon. A cooperative study of juvenile lake sturgeon in the Bad River was started in 1994. The objective of the project is to obtain information on juvenile sturgeon inhabiting the Bad River. Information on distribution, movement, biological characteristics, and habitat condition is collected from juvenile sturgeon. The project began in 1994 and continued through 1999.

Data collection procedures involved setting two gill nets approximately 200 yards east and west of the mouth of the Bad River. Nets were set and lifted three days each week from June through July and information on water temperature, bottom type and depth is recorded for each set. The number of each fish species caught is recorded for each net lifted. Sturgeon are identified with a unique tag number, total length, fork length, girth, and weight were recorded and the fish are released. Length, weight, and age data are also taken on game species such as walleye, northern pike, smallmouth bass, trout, and salmon. For sturgeon killed during netting operations, sex is determined from gonads, pectoral fins are collected for aging, and stomachs are collected to determine diet.

In 1999, Ashland Fishery Resources Office, Bad River Natural Resources Department, and Red Cliff Tribal Fish Hatchery developed and initiated a plan to utilize multiple capture, egg collection, and rearing methods for Bad River lake sturgeon. The purpose was to determine the feasibility of the Bad River serving as an egg source to augment the Bad River population and to assist rehabilitation efforts in Lake Superior. Eggs were successfully collected and hatched, but no fingerlings were produced. The project is ongoing.

Lake sturgeon larval drift and juvenile distribution in the summer has also been studied on the Bad River. This assessment occurs periodically when agency personnel and funds are available. Objectives include determination of the timing and extent of downstream drift of larval sturgeon, and determination of the duration of residency and habitat utilized by young-of-the-year lake sturgeon. Information on early life history of lake sturgeon is necessary to aid fishery agencies with critical habitat management and rehabilitation efforts.

The primary contacts for this study are Bill Mattes of the Great Lakes Indian Fish and Wildlife Commission, Henry Quinlan of the U. S. Fish and Wildlife Service, Rick Huber of the Bad River Natural Resources Department, and Greg Fischer of the Red Cliff Fish Hatchery. There have been no scientific papers written from this study.

Brook trout Rehabilitation Projects - Historically, brook trout were very abundant in Lake Superior tributaries and areas of the lake near the tributaries, but these populations were severely depressed during the late 1800s and early 1900s. In the early 1990's, a coordinated multi-agency effort began to rehabilitate brook trout populations in Lake Superior. The Lake Superior Committee established the Brook Trout Subcommittee under the auspices of the Lake Superior Technical Committee. The subcommittee completed “Status of brook trout in Lake Superior” in 1997, and in 1999, the Lake Superior Committee adopted the “Rehabilitation plan for brook trout in Lake Superior.”

Fishery agencies have several ongoing projects to study brook trout in the Lake Superior basin. MN DNR conducts a study of brook trout in Lake Superior and north shore tributaries to investigate the status of the populations. Study objectives include identification of remnant populations, population structure below and above barriers, and genetic analysis. The U.S. Fish and Wildlife Service has led cooperative surveys to assess abundance, distribution, movement, habitat use, and life history of brook trout at Isle Royale National Park, Michigan since 1993. A marking study was developed by the Red Cliff Tribal Hatchery and U.S. Fish and Wildlife Service in 1997 to determine the effectiveness and longevity of marking various life stages of Lake Superior strain brook trout utilizing oxytetracycline and temperature fluctuation in both hatchery and lake environments. Radio telemetry tracking was conducted to measure the movements, ranges, habitat use patterns, and spawning behavior of reintroduced Lake Nipigon brook trout at Grand Portage, Minnesota and wild brook trout at Isle Royale, Michigan. In the spring of 1999, as a cooperative effort between the Ontario Lake Superior Management Unit and the Centre for Northern Forest Ecosystem Research placed radio transmitters into the body cavity of 40 brook trout captured in the Nipigon Bay area. The study is designed to quantify habitat use by brook trout and identify locations with suitable habitat.

Most fishery management agencies have collected and continue to collect brook trout tissue samples for genetic analysis. The objective of a Lake Superior genetics study was to survey genetic variation among populations sampled from tributary streams, especially those with remnant populations, or those reported to have had them in the past. Analysis of Lake Superior brook trout populations using microsatellite DNA was initiated in 1998. The goal of the study is to analyze allele variation among single and multi-locus microsatellite DNA characters of Lake

Superior brook trout populations with an emphasis on populations with anadromous life history variants. A report has been completed on the project.

Contact persons regarding brook trout rehabilitation in Lake Superior include;

Henry Quinlan and Lee Newman	U. S. Fish and Wildlife Service
Don Schreiner	Minnesota Dept. of Natural Resources
Ken Cullis	Ontario Ministry of Natural Resources
Greg Fischer	Red Cliff Tribal Fish Hatchery
Mike Donofrio	Keweenaw Bay Indian Community
Mary Curtis	U. S. Geological Survey - BRD

References on brook trout in Lake Superior and the rehabilitation process include Slade (1994), Burnham-Curtis (1996), Newman and Johnson (1996), Newman and Dubois (1997), Tillma and others (1999), Newman and others (1999a and 1999b), Quinlan (1999), and Quinlan and others (1999).

Surveys of Ruffe and Native Fishes - The objective of this study is to measure the relative abundance of the non-indigenous ruffe and other fishes in four south shore tributaries of Lake Superior in order to monitor long-term changes in these fish communities. These tributaries are the Amnicon, Iron, and Flag rivers in Wisconsin, and the Ontonagon River in Michigan. In 1993, the U. S. Fish and Wildlife Service expanded its efforts to monitor abundance of ruffe relative to native fish abundance in ten south shore tributaries to western Lake Superior. These tributaries include the Amnicon, Brule, Iron, Flag, Sand, and Sioux rivers in Wisconsin, and the Black, Mineral, Potato, and Ontonagon rivers in Michigan. The study on the ten tributaries was stopped in 1997 in favor of continuing the study on the original four tributaries. The study has been conducted annually from 1988 through 1999 on the four tributaries, and will continue in the future.

Ruffe abundance increased every year and by 1991, they had become the most abundant species captured in trawl tows. As the abundance of ruffe in the St. Louis Estuary increased, apparent declines in abundance of several native species were noted. A recent statistical analysis, however, has not been able to establish a connection with ruffe. Ruffe were reported at locations outside of the St. Louis Estuary as early as 1988. Results of the study indicated abundant ruffe populations with both fluctuating ruffe and native fish populations in the ten study streams.

The primary contacts this study are Gary Czypinski of the U.S. Fish and Wildlife Service or Mike Hoff of the U. S. Geological Survey - BRD. The primary reference for this study is Hoff and others (1998).

Surveillance For Ruffe - The goal of this study is to locate new populations of ruffe and describe their age and/or size composition. Secondary objectives are to describe the fish community at each location surveyed, and to monitor interior range locations where ruffe had been previously collected to detect increases in ruffe abundance. These objectives address the needs of the Ruffe Control Program by defining the range of ruffe and detecting reproducing populations on the periphery of the range. The findings of this program also assist in monitoring the results of the voluntary ballast water management plan implemented by the Great Lakes maritime industry. Formal surveillance began in 1992 and continued through 1999.

Cooperating agencies in the 1999 surveillance effort included the U. S. Fish and Wildlife Service Ashland, Alpena, and Lower Lakes Fishery Resource Offices, and the Ontario Ministry of Natural Resources. Cooperation from agency partners and the public has expanded the coverage and frequency of ruffe surveillance activity and contributes significantly to its effectiveness. With the Duluth/Superior Harbor as the origin, the detected ruffe range extends to Thunder Bay, Ontario, Canada on the north shore of Lake Superior, the Ontonagon River, Michigan, on the south shore of Lake Superior, and the Thunder Bay River, Michigan, on Lake Huron.

The primary contact for this study is Gary Czypinski of the U. S. Fish and Wildlife Service. Several internal reports are written every year and can be obtained from Mr. Czypinski..

Sea Lamprey Index Surveys - This is an ongoing cooperative project involving the Great Lakes Indian Fish and Wildlife Commission, Wisconsin Dept. of Natural Resources, National Park Service, and the U. S. Fish and Wildlife Service Sea Lamprey Management Program. The goal of the project is to monitor relative and absolute abundance of adult sea lampreys in 13 tributaries to Lake Superior during May to early July. The specific objectives of the project are: to estimate the number of sea lampreys spawning in each tributary, monitor the upstream spawning movements of sea lampreys, and to collect biological data on sex, length, and weight of adult spawning sea lamprey. This project has been taking place every year from 1986 through 1999.

Data collection procedures involve using portable assessment traps or fyke nets to capture adult sea lampreys in the Amnicon, Middle, Brule, Bad, Ontonagon, Firesteel, Misery, Silver, Huron, Big Garlic, Rock, Miners, and Tahquamenon rivers at least three times per week. Dead lamprey are measured to the nearest millimeter, weighed to the nearest gram, and their sex is determined. Live lampreys are transported downstream, marked by clipping one or both dorsal fins according to a marking schedule, and then released back into the river. A different combination of clips is used to identify week of capture and release. The number of live and dead marked and unmarked lamprey captured each sampling day is counted, along with the number of other fish species in the traps or nets. Other exotic species such as ruffe and goby if captured, are counted, sexed, and destroyed. Various environmental conditions are recorded each time the traps or nets are emptied, including water and air temperature, as well as subjective evaluations of river condition and river flow.

The primary contacts for this study are Katherine Mullett of the U. S. Fish and Wildlife Service Sea Lamprey Management Program and Bill Mattes of the Great Lakes Indian Fish and Wildlife Commission. Numerous annual reports summarizing the sea lamprey catches can be found in the annual minutes of the Lake Superior Committee Meeting, from the U.S. Fish and Wildlife Service Sea Lamprey Control Program, or Bill Mattes.

Stream Surveys - This in an ongoing, cooperative project to develop an index of the relative condition of each watershed in Michigan's Lake Superior basin. The objectives include assessing the fish, invertebrates, and habitat which exists in each watershed once every five years.

Most of the streams are surveyed utilizing a Michigan Dept. of Environmental Quality protocol known as Great Lakes and Environmental Assessment Section Procedure #51 (GLEAS 51). GLEAS 51 consists of three parts, including evaluation of the macroinvertebrate community, fish community, and habitat quality. Fish, macroinvertebrate, and habitat quality is scored and compared to reference streams when determining their status. Representative sites of usually more than one station, spaced at least one mile away from another station, selected on each stream, and identified and marked for future reference in each watershed. The fishery surveys are conducted in late September or October. Fish are usually collected using a 12 volt backpack electrofishing device. A minimum of 100 fish are collected from each site. All salmonine species are identified to species, measured to the nearest millimeter and released. All other species are identified to species, enumerated, and released. Warm-water fish communities are evaluated using a rating system, whereas cold-water streams are not ranked but are determined to be meeting standards if at least 1% of the community is comprised of salmonines.

A habitat assessment developed by the MDEQ is used at each site and includes evaluations of nine parameters: (1) bottom substrate, (2) stream embeddedness or the degree to which boulders, rubble, logs, or gravel in run or riffle areas are surrounded or covered by fine sediments, (3) stream velocity versus depth, (4) flow stability, (5) bottom deposition, (6) habitat diversity, defined as the number of pools, riffles, runs, and bends, (7) bank stability, (8) bank vegetative stability, and (9) stream side cover. Each habitat parameter is given a relative numeric value for comparison to other Michigan streams. All of the parameter values are summarized for each site and assigned a relative habitat assessment value of excellent, good, fair, or poor. Macroinvertebrate samples are also collected at all sites using various techniques to obtain a representative sample. A total of 64 tributaries have been surveyed since 1991 and should be surveyed every five years.

The primary contacts for this study are William Taft of Michigan Department of Environmental Quality, Ed Baker of the MI DNR, and Mike Donofrio of the Keweenaw Bay Indian Community in L'Anse, Michigan.

8.4.5 Inland Lakes

Coldwater Lakes Ecosystem Monitoring - This project was initiated in Ontario in 1990 to experimentally evaluate the effects of logging on lake ecosystems, and to provide information about the effectiveness of shoreline buffer strips in preventing those effects. This project is part of a larger integrated program that also addresses timber management effects on cool-water lakes and cold-water streams in Ontario.

The research is based on detailed monitoring of the ecological responses to commercial timber harvest operations, of a small group of headwater lakes and their drainage basins. The study lakes are located 70 km northwest of Atikokan, Ontario and support populations of lake trout, common white sucker, minnows and hundreds of other aquatic plants and animal species. As part of the experiment, two lakes have been clear-cut to the shoreline and one lake retains a buffer of standing timber along the shoreline as described in the Timber Management Guidelines for the Protection of Fish Habitat. To detect ecosystem responses to timber harvest, five years of intensive, pre-harvest monitoring will be followed by five to seven years of post-harvest data collection. Parameters being monitored include meteorology, hydrology, sedimentation, lake Hydrodynamics, water temperature, oxygen levels, water chemistry, phytoplankton and zooplankton populations, aquatic insect communities, fish populations, and watershed characteristics.

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ADDENDUM 8-A - HABITAT REQUIREMENTS FOR LAKE TROUT, WHITEFISH, LAKE HERRING, AND WALLEYE

LAKE TROUT

Life stage	Habitat requirement	Source[1]
Egg	dissolved oxygen levels > 6 mg/l	FHD
	clean, large, rocky substrate composed of cobble and boulders	Marsden & Krueger (1991), Marsden and others (1995)
	interstices 20-120 cm	Kelso and others (1995), Marsden and others (1995)
	water depth of 0.5-4.5 m	Kelso and others (1995)
Juvenile	hatching time April through early July	Peck (1982), Bronte and others (1995)
	sand substrate for age-0 lake trout	Peck (1982), Bronte and others (1995)
	age-0 found in 4-60 m	Peck (1982), Bronte and others (1995)
	< 20 m of water through July	Bronte and others (1995)
	< 10 m of water through July	Peck (1982)
	prefer deep water	FHD
	Mysis important food source	FHD, Bronte and others (1995)
	invertebrates and small fish primary food	FHD
	preferred temperature 11.7^{o}C for yearlings	FHD
	preferred temperatures < 15^{o}C for age-0	Peck (1982)
	upper lethal temperature 23.5oC	FHD
Non-spawning adult	distributed throughout waters < 92 m deep	FHD
	older lean lake trout become pelagic	FHD
	siscowets distributed throughout waters > 55 m deep	
	most lake trout have home range of about 80 km	FHD
	siscowets spend most of time in waters < 4.5^{o}C	FHD
	deepwater ciscoes, sculpins, and terrestrial insects important prey items	
	feed almost exclusively on fish	
	humpers found on reefs near Isle Royale, Caribou Is., and Superior Shoal	FHD
	preferred water temperature 4-18^{o}C	FHD
	usually solitary except during spawning season	FHD

Lake Trout continued

Life stage	Habitat requirement	Source[1]
	dissolved oxygen concentrations > 6 mg/l	FHD
	humpers spawn August-September near tops of reefs as shallow as 18 m	FHD
	adult lean trout return to same spawning site in successive seasons	FHD
Spawning adult	siscowets likely spawn June through November	FHD
	lean trout spawn late September through early November	FHD
	most lean trout spawning occurs mid to late October	FHD
	siscowet spawn in waters > 90 m deep	FHD
	most spawning in lakes, but some in streams	FHD
	lean trout spawning occurs in waters of 0.5-37 m deep	FHD
	critical spawning temperature various from 4.5-14°C	FHD

Lake Whitefish

Egg	eggs hatch from March to May	FHD
	incubation period of 120-140 days at 0.5-1.7°C	FHD
Juvenile	age-0 fish associated with the 17°C isotherm	FHD
Non-spawning adult	distributed from inshore area out to waters < 55 m deep	FHD
	primarily bottom feeder	FHD
	most fish live within a 40 km home range	FHD
	travel in schools	FHD
	feeding usually occurs in soft bottom areas	

Lake Whitefish continued

Life stage	Habitat requirement	Source[1]
Spawning adult	spawn on sand, gravel, and rock in water of 2-23 m deep	FHD
	most spawning takes place during November to early December	FHD
	spawning occurs at temperatures of 0.5-5.5^{o}C	FHD

Lake Herring

Life stage	Habitat requirement	Source[1]
Egg	incubation takes 111-125 days at 3.3-2.4^{o}C	FHD
Juvenile	algae, small copepods, and cladocerans first food of larva	FHD
	predominately plankton feeders, but also feed on smelt and other fish	FHD, Link and others (1995), Hoff and others (1997)
	important food of lean lake trout	FHD
Non-spawning adult	predominately plankton feeders, but also feed on smelt	Link and others (1995), Hoff and others (1997)
	important prey item of lean lake trout	FHD
	dissolved oxygen > 3-4 ppm	FHD
	prefer temperatures < 15-17^{o}C	FHD
	mainly pelagic	
	strong schooling behavior	FHD
Spawning adult	spawn in late fall, typically late November through December	
	spawn at temperatures of 1-5^{o}C	FHD
	spawning occurs in shoal areas as well as in water of 43-46 m deep	FHD
	spawning occurs over most types of substrates	FHD
	spawning takes place some distance from the bottom, as far as 14 m from the surface of the water	

Walleye

Life stage	Habitat requirement	Source[1]
Egg	incubation 14-21 days at 8-15°C	FHD
	optimum temperatures were 6-12°C for fertilization & 9-15°C for incubation	FHD
	survival best on clean gravel and rubble substrate of 2.5-15 cm diameter	FHD
	survival good on mats of vegetation with adequate water circulation	FHD
	poor survival on soft muck and detritus	FHD
	dissolved oxygen > 5 mg/l	FHD
	temperatures < 19°C	FHD
Larva	fry eat zooplankton and insects and start to eat fish at 1.5-2.5 cm long	FHD
	optimal temperature for growth of age-0 fish is 19-25°C	FHD
	optimum temperature for fry survival is 15-21°C	FHD
	fry become benthic at 20-35 mm long, and inhabit water of 0.3-1.2 m deep	FHD
	found in deep or turbid water, or in near substrate and under any cover in day	FHD
	no growth at < 12°C or > 29°C	FHD
	upper lethal temperature 31-33°C	FHD
	dissolved oxygen > 5 mg/l	FHD
Non-spawning adult	fish live in shallow water where have sufficient shelter or turbidity to shield eyes	FHD
	optimum range for dissolved solids 40-80 mg/l	FHD
	consume smelt, shiners, and small herring	FHD
	preferred temperature is 22-23°C	FHD
	upper lethal temperature limit is 33-34°C	FHD
	crepuscular or nocturnal feeding habits	FHD
	dissolved oxygen > 3 mg/l, preferred is > 6 mg/l, lethal is 1 mg/l	FHD
	pH of 6-9	FHD
	tolerant of relatively large amounts of suspended and dissolved organic solids	FHD
	no growth at temperatures < 12°C	FHD
Spawning adult	move long distances after spawning	Schram and others (1992)
	do not spawn at pH < 4	FHD
	spawn in clean, hard substrate mainly, but also sand, vegetation, and sticks	FHD
	spawning occurs at 5-11°C	FHD
	do home to spawning areas	FHD
	spawn in rivers	FHD

[1]FHD = Fish Habitat Database created by the Habitat Advisory Board of the Great Lakes Fishery Commission.

Chapter 9

Developing Sustainability in the Lake Superior Basin

This document replaces LaMP 2000 Chapter 9.

Canoeing on Lake Superior
Photography by USDA Forest Service, Superior National Forest

Lake Superior Lakewide Management Plan
2004

Chapter 9 Contents

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Chapter 9
Developing Sustainability in the Lake Superior Basin

EXECUTIVE SUMMARY

The Binational Program is interested in more than protecting and restoring habitat or reducing toxic chemicals produced and released in the basin. In developing a management plan for Lake Superior, government agencies have pursued the goal of developing regional sustainability to restore and preserve a range of social, economic, and environmental values. This chapter discusses issues and actions relevant to identifying, monitoring, and affecting conditions that affect basin-wide sustainability. In conjunction with the work of other committees in the Lake Superior Binational Program, it provides a basis for assessing where we are as a society in the watershed, projecting how close we are to achieving our “Vision for Lake Superior,” and suggesting how to sustain an ecosystem in the Lake Superior watershed that supports thriving communities in the future.

Various groups interpret the concept of sustainability differently and this lack of agreement on the meaning creates a significant challenge. The definition of sustainability also changes as environmental conditions, scientific understanding, and social priorities change. At the very least, sustainability requires that we conserve existing resources in the basin so that future residents are not left without access to vital elements of daily life.

Any plan for developing sustainability must be flexible and responsive to changes in the social, economic, and environmental conditions of the region. Many argue, as well, that planning for sustainability requires ongoing education and persuasion much more than the implementation of specific laws and regulations. Determining progress toward sustainability requires using several indicators measured over time, interpreting the meaning of those indicators within a social and political context, and demonstrating measurable results. We believe that this chapter outlines a prudent and practical blueprint for beginning the process.

To guide our efforts, we have focused on indicators for five general aspects of regional sustainability: the natural capital of the basin, the quality of life in the area, resource consumption patterns, citizens’ awareness of their capacity to contribute to sustainability, and economic vitality. As an initial attempt to measure these indicators, and following another study endorsed by the Binational Program dealing with the attitudes and values of decision makers in the basin, a “Baseline Sustainability Indicators” project was completed in 2000 to determine the status of basin-wide sustainability. This project examined a wide range of existing databases to also determine the extent to which sustainability trends could be observed without creating new indexes or gathering additional information.

Based on a preliminary review of the database, it seems apparent that a variety of social and economic conditions may threaten the long-term sustainability of the watershed. In particular, a relatively depressed regional economy may be fostering conditions that work against the incorporation of sustainability principles into daily life and that further encourage ill-advised use

of basin resources. However, the data also suggest that various demographic forces may influence the adoption of more benign technology and land use planning on a watershed scale. Overall, research to-date reinforces the fact that humans must be seen as a part of, rather than apart from the Lake Superior ecosystem and that a LaMP should consider ways in which we balance our activities with the rest of the regional ecosystem.

Actions

In addition to collecting data regarding socioeconomic and attitudinal data in the basin, the Developing Sustainability Committee (DSC) of the Lake Superior Binational Program has proposed, initiated, or completed a series of projects. A number of these projects are oriented primarily toward further assessing the status of sustainability in the basin. They include:

- A Sustainable Forestry Criteria & Indicator initiative that identifies monitoring indicators for forestry practices in the basin (including harvesting and resource modification) and establishes a system by which the processes can be periodically assessed in light of the basin-wide sustainability of forest resources.

- A "Community Awareness and Development Review" that seeks to formally survey residents of the basin as well as initiate person-to-person dialogue regarding sustainability issues.

- A review of the status of "Sustainability Education" in the region in order to gain a better picture of the extent to which sustainability principles are currently being incorporated into environmental education programs.

- An examination of the causes of urban and rural sprawl in the watershed.

A number of other projects focus primarily on ways of informing the public's choices relating to social and personal behavior, such as:

- A "Communicating Economic Values" project aimed at improving the visibility and demonstrating the economic importance of natural resource systems in the basin.

- A project that evaluates the value of various economic instruments (e.g., user fees, pollution charges, permit trading programs, performance bonds) applicable to the Lake Superior basin.

- A project promoting water conservation that builds upon Canadian efforts.

- "Marketing Waste Reduction and Energy Efficiency" programs that provide information and assistance campaign tailored to alerting small businesses, health care organizations, and educational systems in the basin to various energy and waste assistance programs.

- A program designed to further facilitate mercury reduction by expanding current emphases on thermostat, button battery, and fluorescent lamp recycling.

These and additional action items, some of which already have sponsors and funding as well as some that represent our "next steps," are listed in Table 9-1.

Table 9-1: Next Steps

Project	Lead Agency/ Funding Source	Funded	Needs Funding
Community Awareness Review & Development Project (Phase I)	Environment Canada, EcoSuperior, Michigan Technological University, and Central Lake Superior Land Conservancy (WDNR, MPCA, & GLNPO funding)	X	
Lake Superior Stewardship/Leadership School Project	U of Wisconsin, WI Coastal Management, Lake Superior Binational Program	X	
Sustainable Forestry Indicator Development	USDA Forest Service	X	
Reviewing the Status of Sustainability Education	Not determined		X
Communicating Economic Values and Teaching the Value of Economic Instruments	Not Determined (unknown funding)		X
Promoting Water Conservation	EcoSuperior	X	
Marketing Waste Reduction & Energy Efficiency	Michigan Department of Environmental Quality	X	
Understanding Sprawl	Northern Michigan University (USDA Forest Service)	X	
Watershed Management Promotion	Not Determined (unknown funding)		X
Environmental Industrial Design Demonstration	Not Determined (unknown funding)		X
Mercury Reduction	U.S. EPA, Environment Canada, Province of Ontario, EcoSuperior, other local, tribal and state projects (see LaMP Ch. 4 for more information)	X	
Promoting Riparian Buffers	Central Lake Superior Land Conservancy (GLNPO funding)	X	
Comparing Sustainability Indicators	Not Determined (unknown funding)		X

9.0 ABOUT THIS CHAPTER

In developing a management plan for Lake Superior, government agencies are pursuing the goal of developing sustainability in the Lake Superior watershed to restore and preserve a range of social, economic, and environmental values. The LaMP 2002 Progress Report (available online at www.epa.gov/glnpo/lakesuperior and www.on.ec.gc.ca/glimr/lakes/superior) now places the subject of sustainability front and center in describing the Binational Program. This updated chapter of the original LaMP 2000 technical document discusses a variety of issues and actions relevant to identifying, monitoring, and affecting conditions relevant to ensuring basin-wide sustainability. In conjunction with the work of other committees in the Lake Superior Binational Program, it provides a basis for assessing where we are as a society in the watershed, projecting how close we are to achieving the Lake Superior LaMP's "Vision for Lake Superior" (see p. 1-3), and suggesting how to sustain thriving communities in the future. Section 9.1 describes the problem. Sections 9.2 and 9.3 lay out the Lake Superior sustainability objective and the current status and trends in sustainability in the Lake Superior basin. Finally, Sections 9.4 and 9.5 outline strategies for future initiatives and next steps toward implementing those initiatives.

9.1 PROBLEM IDENTIFICATION

Typically, when we consider the risks associated with environmental problems in the Lake Superior basin, we rarely look beyond the remediation of existing problems. Watersheds can be rehabilitated; municipalities, industries, and citizens can be held accountable; or the air can be purified and the threat seems to "go away." However, in order to ensure that these problems do not recur, a more fundamental puzzle must be solved: How should citizens around Lake Superior sustain their society so that the Lake Superior of tomorrow is healthy as well? How should they act as a society to realize the "Vision for Lake Superior" which begins this planning document?

People are part of and dependent on the environment. Nonetheless, attempts to encourage people to alter their lifestyles on behalf of the natural environment (and, therefore, themselves) are often met with resistance: "It will cost too much. Jobs will be lost. The science isn't conclusive. It's better than it used to be so there's no need to do anything else. The problem will fix itself." In some cases, these arguments may have merit. However, these arguments often fail to appreciate the risks and impacts on current and future generations. By the time society recognizes the cost to future generations of depleted resources and missed opportunities for sustainable lifestyles, the quality of life for future generations may already be diminished.

The Lake Superior Binational Program represents a rare instance in history when citizens, agencies, and nations band together to address problems and to bring to life a collective vision of a responsible society that plans for the future as it deals with the present.

9.1.1 General Introduction

The Lakewide Management Plan (LaMP) for Lake Superior exists because, under the Great Lakes Water Quality Agreement, society has concluded that our actions in the past and present potentially harm our use of the lake in the future. Assuming that humans and nature can coexist in harmony and that it is possible to have a sound economy and a healthy environment, those living in the Lake Superior basin must begin to develop a sustainable society throughout the region. That is, we need to find a way to use resources in the watershed to provide the sort of living conditions we seek to maintain or improve upon, without causing harm. In order to create a sustainable society, it is not enough to guarantee we may benefit from the natural and social environment at the present time. What we do today will surely influence the lifestyles of future generations. Thus, a viable LaMP must take into account the extent to which citizens in the region can prosper and sustain themselves in the years to come.

The drive toward sustainability does not suggest that agencies such as the U.S. EPA should attempt to "manage" society in a way that exceeds their legislative mandates and authority. Rather, it is expected that governments, citizens, and industry will cooperate to limit damage to the natural foundation for society. We face these issues globally as well as in Lake Superior, as we struggle to find ways to improve living standards for a rising world population, while limiting damage to the ecosystem and preserving resources for the future. In order to accomplish these goals, we will need to find ways to support high living standards with less waste of resources and less environmental damage. A resource rich area such as the Lake Superior watershed cannot be insulated from the problems facing others on the planet and, specifically, those living down stream in the Great Lakes catchments.

9.1.2 Defining Sustainability

Various definitions of "sustainability" have been advanced. Some, such as the United Nations definition, have focused on how society can develop in order to meet "the needs of the present without compromising the ability of future generations to meet their own needs." Others have stressed ways to ensure economic growth, as in "the intensive use of, and high yields from, natural systems without damage to their continued productivity." And still others have concluded that the term entails a significant shift in how humans think about their relationship to nature, and have argued that our only hope lies in a substantial retreat from the quality of life enjoyed by those in the industrialized world.

Despite differences of opinion, definitions of "sustainability" generally share a variety of attributes. Planning for sustainability always involves making decisions about where we want to be in comparison with existing conditions. At the very least, sustainability requires conserving existing resources so that our descendants can enjoy the same or better quality of life as the present generation. Additionally, in order to predict how we may best ensure regional sustainability, we need to bear in mind a variety of issues:

- What is or is not sustainable at a given point in time may not be the same in the future. An understanding of what constitutes sustainability will always be a moving target because we cannot control all of the social and environmental factors that are associated with the process of sustaining valued lifestyles. Thus, any plan for developing sustainability must be flexible and responsive to changes that follow social and natural cycles such as migration trends, climate change, or technological development.

- Social and economic considerations are important, but they do not take precedence over a healthy, natural environment that is protected from significant human-induced impairments such as pollution, habitat loss, and chaotic land-use patterns. There is evidence in the basin both of impairments caused by historical resource extraction operations, and of the beginnings of urban sprawl. Both threaten to stress the natural ecosystem and possibly reduce its ability to repair itself or sustain the people that depend upon its bounty. Although social and economic needs must not be neglected, we must recognize that our physical environment is the foundation for all other social or economic benefits. Consequently, sustainability requires that our use of natural resources does not cause substantial long-term damage to the rest of the ecosystem.

- As a dynamic process, developing and measuring sustainability requires attention to how society and the environment change over the span of many years; the true measure of a sustainable society is on the scale of generations rather than years. Planning and assessment is a much more complex process than, for example, rehabilitating a single stream or eliminating a specific chemical in the environment. At times, what we are doing today to maintain a quality of life may diminish the ability of the environment to support society in the future.

- Since processes directed at achieving and maintaining sustainability must be enduring, we need to encourage and respect a diversity of perspectives regarding the manner in which society makes progress toward sustainability. Effective policy truly depends on a political consensus that favors long-term advances over short-term benefits. Planning for sustainability requires ongoing education and persuasion rather than merely attempting to enforce laws and regulations that may not be wholly supported by citizens.

The LaMP process embraces a number of sustainability principles. These principles have evolved over time, are similar to those adopted by other organizations and regional ecosystem initiatives, and are relatively easy to understand.

1. <u>Adaptability</u>. Economic growth and social development in the basin should continually be adapted to the natural cycles of our environment. Value-laden decisions regarding land use should be based on our best scientific understanding of how technology, economics, and society can affect the sustainability of the natural ecosystem.

2. <u>Equity</u>. No group in the basin should bear an inequitable burden in adapting to the natural cycles of our environment. Too often, decisions based on ostensibly sound science do not consider the social ramifications for choosing one action over another and are, in of themselves, politically unsustainable. Furthermore, by design or happenstance, such decisions can place at a disadvantage some segments of society simply because of economic status, geographic location, age, race, sex, or the like.

3. <u>Knowledge</u>. Education, more than regulation, is a cornerstone in the process of brining into balance human activities and the natural cycles of our environment. In particular, the

success of the Lake Superior LaMP depends on basin citizens understanding that a diversity of life and quality habitat is part and parcel of our quality of life.

4. Unity. The basin is a system of interconnected environmental, economic, and social systems. Planning should be done in accordance with the cycles of the natural environment by looking at the "big picture" of how individual decisions affect other areas of the basin and its environment, economy, and society as a whole.

5. Limits. The environment has a finite capacity to replenish natural capital or absorb waste. Science cannot give us an exact measure of the environment's capacity to perform these services. Consequently, the LaMP calls for monitoring a variety of ecosystem indicators, including those focusing on social and economic elements.

9.1.3 Challenges

Even though the idea of sustainability has long provided a foundation for the Lake Superior Binational Program, it is difficult to decide how we should go about facilitating sustainable practices on the ground. To promote practices that provide for sustainable outcomes requires consideration of a variety of issues that go beyond the prevention of pollution; to produce a truly sustainable society means that we must grapple with issues that are more general in scope than those associated with other aspects of the LaMP. Though progress has been made, we are still a long way from promoting a full range of social and economic initiatives that will make for a sustainable future.

In order to effectively support the process of developing sustainability in the Lake Superior basin, the LaMP must deal with three fundamental issues. For each of these issues, there are challenges that must be overcome.

9.1.3.1 Dealing with Complexity

As there is no single best indicator of sustainability, we must turn to a suite of measures taken over time. Some of these indicators are tangible and can be measured in much the same way as the ground water pollution or wildlife populations. Most measures are much less concrete and attempt to assess the distinctly social fabric of the watershed. To integrate physical and social assessments of sustainability requires a substantial investment in time, effort, and finances especially for the creation of new indexes to measure complex social interactions. It also requires the development of reports that are easily understood by citizens and policymakers alike. Additionally, we need to focus on the basin as a whole, rather than become fixated on one or two components of the larger system. There may also be some merit in considering the extent to which actions enhancing regional sustainability could either enhance or adversely affect global conditions (e.g., placing a moratorium on logging, mining or other extractive actions in the watershed might result in the use of developing countries' resources beyond sustainable levels). It is particularly difficult to comprehend this "big picture" since indicators of sustainability are not adequately monitored.

Sustainability does not involves quick-fix, “end-of-pipe” solutions to environmental threats, rather it deals with the identification, monitoring, and remediation of more serious shortcomings located “up stream” in society itself. For example, the Lake Superior Binational Forum has argued that present levels of economic production and consumption are unsustainable, unless we can find ways to produce and consume with less waste and less environmental damage. Ecological deficits must be corrected, globally and in the Lake Superior basin. The Forum argues that globally, and in Lake Superior, ecosystem carrying capacity is being exceeded.

9.1.3.2 Dealing with the Political Context

Observing and modifying social practices is often a more time consuming process than installing the best technology for pollution prevention or remediating a degraded stream. We exist within a political context that can hinder changing the way we live and work, or may as easily provide additional opportunities for sustainability. Our society is one of competing agendas, alliances, and philosophies, and much depends upon what sector of society is driving the political process. Efforts to promote sustainability must cope with competing jurisdictions, lack of coordination, overlapping mandates, and unclear lines of accountability. For instance, an important challenge in promoting sustainable development will be to encourage local governments to consider principles of sustainability, including consideration of impacts on other communities, when making local decisions about management of land and water resources.

9.1.3.3 Demonstrating Measurable Results

It is difficult to determine whether progress is being made towards sustainability. While commitment to sustainability may promote actions that will gradually improve the ability of the Lake Superior ecosystem to support the social and economic lives of its inhabitants, these results may not be immediate. As a consequence, people may focus on more observable short-term targets when committing money or effort to a LaMP-related project. Therefore, it is crucial that we specify reasonably tangible measures and outcomes that permit us to actually observe movement toward sustainability.

9.2 SUSTAINABILITY OBJECTIVES AND INDICATORS

In the process of building the Lake Superior LaMP, the Developing Sustainability Committee (DSC) of the Binational Program has relied on a consistent set of ecosystem targets established in the mid-1990s (see: http://www.cciw.ca/glimr/lakes/superior/pdf/lsupind5.pdf). Both the general- and sub-objectives for sustainability were created out of public input and in consideration of environmental and social science. Subsequent efforts by the DSC refined those objectives to highlight the social and economic conditions influencing environmental sustainability. In comparison with most outcomes identified in other portions of the LaMP, these objectives are cast in terms of assessing human behavior that affects the land, water, air, and life forms in the watershed.

9.2.1 General Objective

In keeping with the Vision, the following objective underscores a distinctly social aim for our efforts in the basin, focusing primarily upon how we should go about the business of using resources at our disposal:

> Human use of the Lake Superior ecosystem by all people in the watershed should be consistent with the highest social and scientific standards for sustainable use. Land, water and air use should not degrade the Lake Superior ecosystem, nor any adjacent ecosystems. Use of the basin's natural resources should not impair the natural capability of the basin ecosystem to sustain its natural identity and ecological functions, nor should such use place at significant risk the socioeconomic and cultural foundations for any group of citizens in the watershed, nor should we deny current and future generations the benefits of a healthy, natural Lake Superior ecosystem. Policies directed at the wise management of natural and social resources in the basin should not usurp the right of local communities to determine their future within the guidelines established by existing statutes and regulations. Technologies and development plans that preserve natural ecosystems and their biodiversity should be encouraged.

There are a number of noteworthy features embedded within this general objective:

- Promoting sustainability requires involvement by government, industry, and private citizens alike.
- Decisions should be based on our best scientific understanding of how technology, economics, and society can affect the sustainability of the ecosystem.
- No particular sector of current and future society should bear an inequitable burden in implementing sustainable practices.
- Communities within the basin should be empowered to lead the way toward sustainability.
- Education, more than regulation, is the cornerstone to achieving sustainability.

Ideally, the general objective can provide guidance in identifying specific, action-oriented principles that can shape social behavior.

9.2.2 Sub-Objectives

To evaluate our progress, the general objective has been broken down into four sub-objectives. These guide us in the selection of monitoring and projects toward achieving sustainability in the Lake Superior basin.

9.2.2.1 Ensuring Environmental Integrity

The first sub-objective, that "public and private decisions should be based on understandings, rooted in formal and informal educational settings, which contribute to the integrity and stability of social and biotic communities," reaffirms the role of education in creating a sustainable regional society. We should be promoting a range of educational opportunities that help people to appreciate the need for living in harmony with the natural ecosystem in the basin.

9.2.2.2 Resources and Services as Environmental Capital

The second sub-objective clarifies the relationship between resource use and resource value: "The Lake Superior ecosystem provides resources and services to humans. These include air, water, fiber, minerals, energy, waste transport and treatment, food, recreation, and spiritual sustenance. These resources should be valued as environmental capital, in the same way that other capital is assigned value."

Much of the work required to meet the second sub-objective can be accomplished by having ordinary people invest themselves in the LaMP, or in other efforts that seek to enhance the quality of life locally or regionally through more sustainable resource management. When citizens become involved in the Binational Program and similar efforts, they increase the "social capital" of their communities. Social capital includes the knowledge and experience that people bring to any production capacity and refers to the organizations, structures and social relations that people build, independent of any state or large corporation. In turn, enhancing social capital can help reserve environmental capital. For example, research is demonstrating that with the presence of strong social capital, consumption patterns can be decreased without any decrease in quality of life.

9.2.2.3 Sustainable Technology and Design

"Institutional capacity to integrate affordable technology and sustainable design should be developed within the Lake Superior ecosystem." Here, the focus is upon encouraging the adoption of practical technology that is within financial reach of citizens who work and play in the region.

9.2.2.4 Basin-Wide Planning

The final sub-objective for developing sustainability within the LaMP framework suggests projects that optimize regional land-use planning: "The basis for guiding sustainable development at the scale of the Lake Superior ecosystem (especially in reference to community land use or comprehensive planning) should be the pattern of land, water, and air use, as these affect ecological, social, and economic processes." In particular, we should be careful to monitor where we are in process of striving for sustainability, so as to better identify the specific actions needed in the future. Furthermore, we should recognize that while state/provincial and federal policy can be influential, it is the local units of government that generally have jurisdiction over the use of the land. And, sometimes, regulations from beyond a locality may undermine the ability of local units of government to direct resources in more appropriate ways.

A useful idea regarding sustainability considers the "ecological footprint" a community leaves on the planet as it develops and consumes natural resources. Our ecological footprint is the total area of productive land and water required continuously to produce all the resources consumed, and to assimilate all the wastes produced, by a specified human population, wherever on Earth that land is located. Through the use of sophisticated computer algorithms, decision makers can estimate the true costs and benefits flowing from any land use decision. Coupled with Geographic Information Systems technology, ecological foot printing analysis can be used as a compass directing us toward sustainable lifestyles. Though ecological foot printing analysis is still in its infancy and still requires a significant investment in research and development, this analytical tool holds great promise for the Lake Superior basin and beyond.

9.2.2.5 Sustainability Indicators

In 1995, the Lake Superior Binational Program published a discussion draft document entitled Ecosystem Principles and Objectives for Lake Superior (EPO), which was developed on the basis of input from experts and citizens living in the basin rather than simply incorporating measures originating elsewhere. The EPO report included a detailed summary of the rationale and specific monitoring indicators for basin-wide sustainability; a complete version of the "developing sustainability" portion of that document can be accessed via the World Wide Web at http://www.cciw.ca/glimr/lakes/superior/pdf/lsupind5.pdf. In 1998, so as to better monitor the status of regional sustainability, the Superior Work Group narrowed the wide range of sustainability indicators in the EPO to a suite of five "best bet" measures. The following categories of sustainability indicators provide a framework for assessing the status of and progress toward achieving sustainability in the Lake Superior watershed:

- Reinvestment in the Natural Capital of the Basin. One way to think about managing human activities as a part of the Lake Superior ecosystem is to consider the concept of "natural capital." Just as people often measure their wealth in terms of currencies and possessions, so too does the natural environment represent an enormous bank of goods and services. To the extent it is unwise to use all of our money for short-term gains or to consume all of our material resources with little care for the future, it is also foolish to deplete an ecosystem of all the benefits we rely upon. Certainly, some of these natural riches are more-or-less renewable, as is the case of sustainable forestry. On the other hand, other types of natural resources (e.g., a diversity of species, or the ozone layer) are non-renewable. Natural systems have a finite capacity to produce renewable resources or to absorb human-induced emissions and pollutants without heavy impact on future generations. Hence, we must ensure that annual consumption of natural resources is not depleting basic natural capital "stocks" and that there is enough natural "wealth" to meet our needs and those of future generations.

  Given the substance of natural capital, we want to monitor the balance between what is extracted from the natural basis for life in the basin with what is returned to the land, and to promote projects that facilitate an equitable balance in the future. Thus, this suite of indicators includes: the amount of sustainable forestry occurring on the land; the extent of watershed management or restoration programs; native fisheries and wildlife stocking; exotic species control and native plant repatriation; reclamation of mining operations and industrial sites; and replacement of wetlands and biotic diversity.

- "Quality of Human Life" Indexes. Several existing EPO indicators focus on the extent to which natural and social forces in the watershed impact upon citizens' lifestyles (e.g., migration patterns, social service demands). This omnibus measure of life, incorporating a range of social indicators, serves as a basis for projects intended to benefit the quality of life in the basin in accordance with other ecological or economic values. For example, with baseline measures in hand, we can compare the quality of life in different communities, institute remedial programs, and track changes over time. This suite of indicators includes: incidence of crime; demographics of migration (especially the loss of extended families in the basin); demands for social services; transportation infrastructure status; extent of recreational and cultural opportunities; citizen involvement in decision making; public access to lakeshores; and population density.

- Resource Consumption Patterns. We should consider the types and quantities of resources that are consumed in the basin, especially as these demands influence various natural and social structures. In particular, we want to focus on energy production and consumption, water availability and use trends, and waste stream loadings (e.g., landfill capacity versus recycling trends). This suite of indicators includes: availability of recycling programs; amount of forest and mining resources that remain in the basin; types and quantities of electric power generation; quality and volume of aquifers; amount of and stressors related to tourism; depletion of wildlife and fisheries; landfill capacity and incineration volume; degree of urban sprawl; and loss of native flora.

- Awareness of Capacity for Sustainability. Clearly, education in formal and informal settings is a necessary component in any drive toward regional and global sustainability. And education is especially important if we are committed to fostering sustainability through processes of voluntary compliance rather than by way of regulation and enforcement. We need to understand the content and extent of current educational and media messages about issues related to sustainability, and measure the impact of improved educational programs on people's awareness of sustainability and on their behavior. The indicators needed include: depth of environmental and sustainability education curricula in schools; promotion of resource conservation programs; incorporation of ecological design into building codes; extent of zoning regimes; popular support for environmental regulations; community outreach programs by natural resource agencies; and media coverage of sustainability-related issues. It should be noted, however, that monitoring trends in this suite of indicators will be difficult given the inherent subjectivity of what actually constitutes "awareness." For example, the Clean Michigan Initiative overwhelmingly supported by voters in 1998 was derided by some environmental organizations as favoring urban economic interests at the expense of larger environmental needs. Nonetheless, funding from that initiative is now supporting a number of remediation projects that contribute to sustainability. In this case, it is difficult to determine which group (i.e., voters, policy makers, non-governmental organizations) actually demonstrated a greater awareness of the issues at hand.

- Economic Vitality Measures. Any broad-scale program to ensure a sustainable world must give due consideration to economics along with issues of ecology and society. Without a healthy economy, social and environmental policies in a democratic system are not in themselves sustainable. The broader Binational Program can be well served by our understanding the threats and opportunities to the economic health of the watershed, drawing upon extant econometric models of vitality, and communicating such patterns and trends to the public. For example, while it is arguable that those living in poverty have a lesser impact on the ecosystem due to their relatively meager capacity to participate in a consumer society, the opposite could be just as true insofar as poverty may hasten the depletion of wood lots, require the diversion of community resources that could be directed at environmental protection, and so on. Furthermore, with a baseline overview of the economy, projects can be implemented to demonstrate sustainable alliances between environmental and economic sectors in the basin. This suite of indicators includes: per capita income; cost of living; extent of poverty; local employment trends; regional trade balance; diversity of community economies; facilitation of transitional economics; value-added industry; and regional or local tax bases.

In 2000, the Binational Program hosted a workshop designed to bring together experts in the field of ecological and social assessment (report available at http://www.epa.gov/glnpo/lakesuperior/binatmonwkshp.pdf). Building upon the work that went into developing the EPO seven years earlier, independent analysis by members of the Lake Superior Binational Forum has added to the list of indicators a number of alternative measures while, at the same time, suggesting that some may be more valuable than others. Table 9.2 displays the decade-long evolution of the sustainability indicators now in use by the Binational Program.

Table 9-2: Comparison of the LaMP 2000 and Forum Sustainability Indicators

Forum Sustainability Indicators Bold indicates the most direct DSC-Forum match	**LaMP 2000 "Best Bet" Indicators - Measures for Sustainability**
Reinvestment in the Natural Capital of the Basin	
• **Sustaining basin diversity.** • **Landscape patterns.** • **Reinvestment in natural capital.** • Political pressure to protect and remediate the environment. • General participation in environmental programs	Amount of sustainable forestry occurring on the land.
• **Sustaining basin diversity.** • **Landscape patterns.** • **Reinvestment in natural capital.** • Improvement in water quality. • Political pressure to protect and remediate the environment. • General participation in environmental programs	Extent of watershed management or restoration programs.

• **Sustaining basin diversity.** • **Reinvestment in natural capital.** • General participation in environmental programs	Native fisheries and wildlife stocking.
• **Sustaining basin diversity.** • Reinvestment in natural capital. • General participation in environmental programs	Exotic species control and native plant repatriation.
• **Reinvestment in natural capital.** • **Political pressure to protect and remediate the environment.** • Landscape patterns. • Diversity of community economies. • General participation in environmental programs	Reclamation of mining operations and industrial sites.
• **Sustaining basin diversity.** • **Reinvestment in natural capital.** • **Improvement in water quality.** • Landscape patterns. • Reduced waste stream loadings. • Political pressure to protect and remediate the environment • General participation in environmental programs	Replacement of wetlands and biotic diversity.

"Quality of Human Life" Indexes

	Incidence of crime.
• **Robustness, human flexibility, and adaptability**	Demographics of migration.
	Demands for social services.
• **Energy consumption.**	Transportation infrastructure status.
• **General participation in environmental programs**	Extent of recreational and cultural opportunities.
• **Political pressure to protect and remediate the environment**. • **General participation in environmental programs**	Citizen involvement in decision-making.
• Landscape patterns.	Public access to lake-shores.
• **Landscape patterns.** • Energy consumption.	Population density.

Resource Consumption Patterns

• **Reduced waste stream loadings.** • **Political pressure to protect and remediate the environment.** • Reinvestment in natural capital.	Availability of recycling programs.
• **Sustaining basin diversity.** • **Regional trade balance.** • **Diversity of community economies.** • Reinvestment in natural capital.	Amount of forest and mining resources that remain in the basin.
• **Energy consumption.** • **Reduced waste stream loadings.** • Regional trade balance.	Types and quantities of electric power generation.
• **Improvement in water quality.** • Reinvestment in natural capital.	Quality and volume of aquifers.
• **Regional trade balance.** • **Diversity of community economies.**	Density of and stressors related to tourism.
• **Sustaining basin diversity.** • **Reinvestment in natural capital.**	Depletion of wildlife and fisheries.
• **Reduced waste stream loadings.** • Reinvestment in natural capital.	Landfill capacity and incineration volume.
• **Landscape patterns.** • **Political pressure to protect and remediate the environment.** • Reinvestment in natural capital. • Energy consumption.	Degree of urban sprawl.
• **Sustaining basin diversity.** • Reinvestment in natural capital.	Loss of native flora.

Awareness of Capacity for Sustainability

• **Political pressure to protect and remediate the environment.**	Depth of environmental and sustainability education curricula in schools.
• **Political pressure to protect and remediate the environment.** • Improvement in water quality. • Reinvestment in natural capital. • Energy consumption. • Reduced waste stream loadings.	Promotion of resource conservation programs.
• **Political pressure to protect and remediate the environment.** • Reinvestment in natural capital.	Incorporation of ecological design into building codes.

• Energy consumption. • Reduced waste stream loadings. •	
• **Landscape patterns.** • **Political pressure to protect and remediate the environment.**	Extent of zoning regimes.
• **Political pressure to protect and remediate the environment.** • Reinvestment in natural capital.	Popular support for environmental regulations.
• Political pressure to protect and remediate the environment.	Community outreach programs by natural resource agencies.
• **Political pressure to protect and remediate the environment.**	Media coverage of sustainability related issues.

Economic Vitality Measures	
	Per capita income.
• Energy consumption.	Cost of living.
	Extent of poverty.
• Diversity of community economies.	Diversity of community economies.
• **Regional trade balance.** • **Diversity of community economies.**	Local employment trends.
• **Regional trade balance.**	Regional trade balance.
• Regional trade balance.	Facilitation of transitional economies.
• **Regional trade balance.** • **Diversity of community economies.**	Value-added industry.
• Diversity of community economies.	Regional or local tax-bases.

Forum Indicators1	***Indirect "Best Bet" Indicators***
• Robustness, human flexibility, and adaptability.	All of the "Reinvestment in the Natural Capital of the Basin" suite; citizen involvement in decision-making; all of the "Resource Consumption Patterns" suite; all of the "Awareness of Capacity for Sustainability" suite; extent of poverty; diversity of community economies; facilitation of transitional economies.

• Ecological literacy.	All of the "Reinvestment in the Natural Capital of the Basin" suite; citizen involvement in decision-making; all of the "Resource Consumption Patterns" suite; all of the "Awareness of Capacity for Sustainability" suite; facilitation of transitional economies.
• Basin-wide sense of identity.	Extent of watershed management or restoration programs; extent of zoning regimes; media coverage of sustainability-related issues.

[1] These 3 indicators, though potentially rich in information regarding the development of sustainability in the Lake Superior basin, will likely require both many different sub-measures and the expenditure of extensive resources, in order to gather reliable and valid data.

The foregoing set of "best bet" indicators for developing sustainability served as the basis for initiating two projects, each of which address the sub-objectives of education, economic relationships, incorporation of practical technology, and land-use planning.

9.3 CURRENT STATUS AND TRENDS IN THE BASIN

9.3.1 Baseline Sustainability Indicators Project

In 2000, the Developing Sustainability Committee (DSC) reported on its baseline data for a suite of socioeconomic sustainability indicators. Although the project researchers had to rely on data generated by various agencies at sporadic intervals, this "snapshot" of human dimensions relevant to regional ecosystem management in the Lake Superior basin is instructive. Table 9.3 identifies some of the important trends found in this extensive report (available at http://emmap.mtu.edu/gem/community/planning/lsb.html).

Table 9-3: Representative Trends in Basin-wide Sustainability

Forestry
Michigan, Minnesota, Wisconsin, and Ontario have a number of programs to encourage sustainable forestry, and voluntary compliance with those standards seems to be working. For example, the Great Lakes Forestry Alliance reported in 1995 that timber growth in Michigan, Minnesota, and Wisconsin exceeded harvest by 90 percent and timber volume increased from about 25 billion cubic feet in 1952 to more than 50 billion cubic feet in 1992. In the United States, there are 51.5 million acres of forestland in the basin, of which 3.2 million acres are either reserved as parks and wilderness or classified as unproductive. Of the productive land, 26 million acres are nonindustrial private forests, 18 million acres are publicly owned, and forest-products companies own 4 million acres.

Population & Migration
One measure of sustainability considers the number of people the basin can contain without jeopardizing environmental infrastructure. Here the situation is more complex that it may at first appear. Although population in the U.S. portion of the basin has declined roughly 4 percent in

the past half-century, and 80 percent of the residents tend to remain in the same geographic area for lengthy periods of time.

Transportation
Given the rural nature of the Lake Superior basin, transportation could have a substantial impact on sustainability. In this area, trends are in a negative direction. For example, between 1980 and 1990, the percentage of basin workers driving alone to work rose from 58 to 73 percent, while fewer carpooled or walked to work and a limited survey of traffic volumes in the Michigan part of the Basin from 1987 to 1998 shows an average 34 percent increase in traffic in regional population.

Recycling
Participation in recycling programs is much higher and materials recovery greater in Minnesota and Wisconsin, where statewide programs are well-developed and certain materials are banned from landfill disposal. Large areas of the Michigan part of the Lake Superior Basin have no recycling programs at all, and very little information is available on Ontario programs. Consequently, the total post-consumer waste disposed by landfill or incinerator appears to exceed 2 million cubic yards per year.

Energy Production
About 87 percent of the electric power generated in the Basin comes from generators using coal, natural gas, fuel oil, or wood waste. Total power generated in the U.S. part of the Basin increased 47 percent between 1985 and 1995. More than half of basin-wide water usage supports energy production. The amount of power purchased from outside the basin has also increased. From this we can conclude that basin residents are consuming nonrenewable resources at an increased rate. Prudent conservation practices could likely reduce this consumption rate.

Economy
"Economic Vitality" is one of the best-represented indicators in the Developing Sustainability Committee (DSC) report, and represents a central element in assessing forces that compel people to live in an unsustainable manner. Median family and household incomes within the U.S. Lake Superior Basin were below the national and Michigan, Minnesota, and Wisconsin medians in 1979 and 1989 but were improving somewhat by 1993. The poverty rate for all persons, families, and children increased faster in the U.S. portion of the basin between 1979 and 1989 than in the U.S. overall during that period. Seven industries (non-durable goods manufacturing, durable goods manufacturing, retail trade, mining, transportation and public utilities, federal civilian government, and construction) were among the top three industries in six or fewer counties each, suggesting an increase in economic diversity leading to more sustainable communities.

More recently, the DSC has partnered with Michigan Technological University to expand the baseline indicators project so as to develop land-use indicators. In light of the political ramifications of developing sustainability, and in conjunction with the State of the Lakes Ecosystem Conference (SOLEC) process, this research (funded by a grant from the Great Lakes National Programs Office) investigated the extent of local land-use planning structures and existing links between citizen groups and governments, both of which were shown to be fragmented and sporadic (see http://emmap.mtu.edu/gem/community/planning/solec.html).

9.3.2 Survey of Community Decision Makers

In 1997, at the request of those who manage “protected areas” (i.e., public parks and preserves) in the Lake Superior basin, the Binational Program co-sponsored an extensive survey of community decision makers in the region (for the full, peer-reviewed report, see *Natural Resources Journal*, volume 40 – number 1, pages 19 – 46). Based on the assumption that “core” protected areas in the region serve as a primary focus for ecosystem management practices, and that their existence contributes significantly to the social and economic well-being of basin residents, business and industrial leaders, educators, media managers and governmental representatives reported their perceptions regarding the relationship between protected areas in the basin and sustainable development. Research objectives included the production of a representative profile of basin decision makers’ knowledge of and attitudes regarding the role of protected areas in the respondents’ social and economic spheres.

The results of this study indicate that, in general, respondents from Canadian communities showed more positive attitudes toward the role of protected areas, as well as a more unified perception of issues, than respondents from the United States. Most community leaders seemed to have a good general knowledge of the natural areas near where they live and held a favorable opinion of government management of protected areas, while rejecting the idea that private enterprise could accomplish the task as well. Also, it is evident from the results of the survey that the majority of community leaders believed that the inherent ecological values of protected areas may be compromised by private enterprise and that it would be difficult for entrepreneurs not to be biased by profit margins at the expense of protected areas’ values. However, although respondents demonstrated a positive perception of protected areas and their relationship to sustainability across the basin, a large portion of the community leaders believed that existing parks and refuges should allow for more development and resource extraction and either rejected or were unsure about the desirability of creating more protected areas in the region. Despite the fact that most respondents believed that protected areas should include portions of Lake Superior itself, they seemed to be less sure of the role of aquatic protections in their own backyard. It is probable that most basin residents are unfamiliar with what aquatic protections involve, what restrictions may be implemented, and the environmental, social, and economic benefits that may evolve from such a designation.

Community leaders generally perceived protected areas as contributing to their communities in relation to the tangible benefits that accompany fostering sustainable development. Yet they exhibited less favorable attitudes towards preservation of protected areas in their own vicinity than in general. For instance, respondents were less opposed to resource extraction in local protected areas; were less accepting of restrictions being placed on local protected areas; had a slightly less favorable view of the economic burdens posed by nearby protected areas; and were less agreeable to preserving aquatic regions near their communities. This response pattern suggests that community leaders are perhaps less accepting of environmental policies when they perceive local economic growth and job opportunities to be at risk. Hence, this study provides evidence in support of the idea that citizen' attitudes toward natural resource policies and protected areas are grounded in local, rather than regional, national or global concerns over economic viability and lifestyle choice.

This study suggests that basin residents are generally ambivalent toward the prospect of protected areas or sustainable development in the region. People understand that protected areas are important but lack sufficient information about the general range of benefits afforded by parks and preserves. Hence, information campaigns about the benefits of preserving natural lands are needed to better inform debates about natural resource policy

9.3.3 Summary of Status and Trends

Given the relative paucity of baseline data we have accumulated thus far (especially that of Canadian origin), it is somewhat premature to draw general conclusions regarding the status and prospect for basin-wide sustainability in the Lake Superior region. Such will require the generation and analysis of data over time, as well as a careful cross-referencing of information. Furthermore, since much of our data deals with mostly economic concerns, we should be wary of unduly emphasizing economic sustainability over social and environmental components in the sustainability triad. And it may be significant that much of the data does not account for economic and social changes that have accompanied the general economic upswing of the late 1990s. Nonetheless, even at this early date we can make a number of observations regarding opportunities for education, general understandings of economic relationships, incorporation of practical technology, and wise land-use planning that may be tested as information comes to augment the research reported above. For example:

- Although the high educational background of basin residents and environmental education efforts seems to be cultivating pro-sustainability understandings and values, the relative impoverishment of the region may further encourage continued inefficient consumption of watershed resources (e.g., previously undisturbed countryside). To compensate for such consumptive drives, we must find ways to enhance the regional economy in ways that balance social and environmental needs.

- The relatively lower cost of living in the region (e.g., housing costs), combined with a seemingly higher quality of life (e.g., low commuting times and crime rates), may attract more immigrants to the region, thereby placing greater stress upon natural and social systems to the detriment of sustainability. Consequently, land use patterns are impacted by newcomers' inclinations to develop home sites and services beyond the existing suburban fringe, thereby reducing the amount of agricultural, forestry and recreational lands.

- As urban populations decline, and more people move into undeveloped countryside, greater pressure will be placed on transportation and service infrastructures; with rising levels of poverty and lowered tax-bases, less effort may be directed at conservation-oriented measures such as mass transit and the use of environmentally benign energy sources. Thus, it is imperative that innovative technologies be adopted to offset citizens' tendencies to live for the present and forget about the future.

- As with elsewhere in Canada and the United States, the general population of the Lake Superior basin is aging. It will be important to further enfranchise (e.g., through continuing education and media outreach) this aging population in the collective process of promoting sustainability.

9.4 STRATEGIES FOR FUTURE INITIATIVES

9.4.1 "Gauges" and "Levers" to Promote Basin-wide Sustainability

With the release of LaMP 2000, the Lake Superior Binational Program began implementing a range of projects designed to further promote sustainability in the basin. As noted earlier, the actual implementation of projects will not be an easy task. Any project that monitors or improves the ability of citizens to manage their lifestyles in a sustainable manner must integrate complex data, work within the political context, and demonstrate measurable results. Furthermore, insofar as the projects we envision should encompass a wider field of action than typically associated with specific habitat or pollution remediation or protection projects, the monetary cost of the initiative will be significant. And, without much doubt, we can anticipate that any strategy for change will require a sizable investment in effort from government agencies, regional industries, and citizens in the basin. Consequently, the "commitments" we continue to make must be considered in light of the resources that may or may not become available to support the program.

In the following sections of this chapter we outline a series of projects that we believe can be initiated in the near future. The strategy we have adopted proceeds along two tracks and has been adapted from a framework used by BioForest Technologies Inc. of Sault Ste. Marie, Ontario to develop forest management plans in Canada and the United States. On the one hand, some of the projects are directed at measuring indicators that should be considered gauges of sustainability in the region. Here, the primary focus is upon assessing the extent to which we are moving toward or away from sustainable lifestyles. On the other hand, other projects mostly deal with levers, or attempts to influence and change behavior so as to better promote sustainability. The intent here is to engage citizens in a proactive discussion of the issues at hand, and to encourage sustainable behavior while respecting the variety of viewpoints and values that citizens bring to the discussion. It should be noted that such gauges and levers are not wholly independent of one another; gauging where we are helps leverage projects that modify social conditions, which in turn must be continually monitored. For example, the previously discussed Baseline Sustainability Indicators project provides information that will help guide funding proposals for projects designed to improve conditions on the ground. The questions addressed by this project include:

- To what extent is economic planning compatible with forecasted market demand for products and services? For example, is a shift from an economy based on mining to one based on ecotourism economically feasible?

- To what extent does a change in demographic characteristics (e.g., the flight of younger generations in search of economic opportunities, the growth in a “second home” real estate market) affect the consumption of natural and social resources?

- To what extent do emerging sustainable forestry practices, in comparison with more intensively extractive approaches, maintain the natural capital of the Lake Superior basin?

- To what extent does the current configuration of community economies in the watershed allow for the long-term viability of resource policies?

- To what extent are current efforts to conserve energy and resources reducing the amount of “waste” being discharged into the basin ecosystem?

9.4.2 Promoting Sustainability through Partnerships

It is also important to recognize that the “developing sustainability” component of the LaMP is complemented by the work of other committees in the Binational Program. In a number of cases, the sorts of measures comprising our suite of “best bet” indicators are being monitored and acted upon by other groups. In reviewing the strategies being adopted by other Lake Superior Work Group committees at a monitoring workshop held in 1999, it became apparent that there is an appropriate degree of overlap between thematic emphases in the LaMP: the Habitat Committee is assessing the amount of watershed management and restoration occurring in the basin, wetland replacement rates, lakeshore access, and the growth of urban sprawl; the Aquatics Committee is reviewing the status of native fisheries, wetland fauna, and the quality and volume of aquifers in the region; the Terrestrial Wildlife Committee also focuses on riparian restoration, wildlife depletion and stocking, and the status of native flora and fauna. And, to a varying extent, each committee also includes an education component. We anticipate that substantial efficiencies in time, effort, and money for specific “gauge“ or “lever“-oriented projects will be realized by meshing our sustainability initiatives with those of other committees.

9.5 NEXT STEPS

The Lake Superior Work Group continues to implement a range of ecosystem-based projects. As with the work of other committees, the Developing Sustainability Committee is also forging ahead with its sustainability initiative. The following section briefly outlines the areas of concentration.

9.5.1 "Gauges" to Promote Basin-wide Sustainability

The following projects are primarily aimed at monitoring the extent to which principles of sustainability are understood and incorporated into the actions of a major industrial sector in the basin, the lives of common citizens in the watershed, and educational systems that surround Lake Superior. In addition, each gauge-oriented project points to the types of levers we may wish to pursue if we find a significant disparity between the ideals of sustainability and what is actually happening on the ground.

9.5.1.1 Community Awareness Review and Development Project (CARD)

The drive toward sustainability must be grounded in the actions of local communities but most citizens in the basin have limited understanding of long-term sustainability. There have been some notable attempts to cultivate sustainability awareness in the basin, such as the "sector" workshops hosted by the Lake Superior Forum dealing with issues such as mining, forestry, and sustainability in general. Additionally, collaborations such as the "Thunder Bay 2002" group generated interest in sustainability within specific communities. The CARD project is more comprehensive.

The project, initiated in 2003, will formally survey residents of the basin as well as initiate person-to-person dialogue regarding sustainability issues with the following objectives:

i) to determine the state of knowledge and awareness of the residents of thirteen communities around Lake Superior of sustainability and environmental issues of interest to the LaMP, and identify areas for improvement;
ii) to increase knowledge and awareness, especially as it relates to local issues, e.g., burn barrels, habitat protection; and
iii) to foster improved decision-making that integrates social, economic, and environmental considerations.

The CARD has a three-phase, multi-year approach targeting thirteen basin communities: Thunder Bay, Marathon, Wawa, and Sault Ste. Marie (ON); Duluth, Two Harbors, and Grand Marais (MN); Newberry, Marquette, Houghton, and Ironwood (MI); Ashland and Superior (WI)).

In Phase I, interviews and surveys will be conducted in these communities to assess residents' knowledge of sustainability and the opportunities it provides, as well as other issues of concern, and how environmental considerations affect their behaviour and decision-making. In Phase II, this information will be used to direct outreach activities to various segments of these communities, such as business, county and municipal governments, and civic groups. In Phase III, the effectiveness of these outreach campaigns would be evaluated. The year-to-year activities of the project will be dependent upon the availability of funding.

The Developing Sustainability Committee is leading the Community Awareness Review and Development project with active involvement by the other committees. The results of this project will assist the four committees in accomplishing their objectives more effectively.

9.5.1.2 Lake Superior Stewardship/Leadership School Project

The aim of the project is to develop local leadership skills among youth and adults in the context of Lake Superior basin issues using sustainability as the overarching theme. A pilot project began in 2003 with funding to University of Wisconsin – Extension by the Wisconsin Coastal Management Program. Pilot leadership school programs will be held during the summer of 2004 for youth and adults with an emphasis on experiential learning. The Sigurd Olson Environmental Institute at Northland College and University of Wisconsin Extension will sponsor the second year of the project. The second year will include an expansion of the youth program and a web-based curriculum supporting the needs of the Binational Program. The ultimate goal is to expand the program from the Wisconsin part of the basin to the rest of the Lake Superior basin.

The Lake Superior Stewardship Project is one of the joint projects between the Binational Program Superior Work Group and the Forum. Several agencies and organizations are participating with this project.

9.5.1.3 Sustainable Forestry Practices Inventory

The overwhelming majority of the land-base in the Lake Superior basin consists of "working" forests administered by public agencies and private organizations. Currently, a range of sustainable forestry practices have been instituted on these lands: the Ontario Ministry of Natural Resources follows "adaptive management" practices on Crown Land, the Canadian Standards Association promotes forest-product guidelines, U.S. companies typically adopt Sustainable Forestry Initiative criteria or self-imposed targets through the International Standard of Operation process, State lands have begun to standardize their practices, and the USDA National Forest Service has its own regimes. However, we do not have a compendium of (among other issues) the scope, structure, administrative guidelines, yields, or efforts to coordinate with adjacent local and regional management practices. Such baseline data would be useful in projecting trends in the reinvestment in natural capital pertaining to basin flora, suggesting avenues for educational outreach, and assessing the projected economic vitality of the watershed. Thus, this project consists of comparing and contrasting sustainable forestry practices in the basin (including harvesting and resource modification) and establishing a system by which the processes can be periodically assessed in light of basin-wide sustainability of forest resources, including those beyond a historical emphasis on fiber production.

One outgrowth of developing an inventory of sustainable forestry practices may be an eventual partnering with government and industry to maximize sustainable yields while protecting the larger ecosystem and serving residents of the basin well into the future. For example, the Ottawa National Forest has already committed itself to developing and refining local forest unit criteria and indicators for sustainable forestry. The project goal is to identify and test the conditions that are necessary to sustain ecological, economic, and social systems, and the measures needed to assess how forest management is influencing sustainability at the local level. The ultimate utility of this effort will be to provide forest managers and partners with feedback that can be used to monitor and improve forest management planning. Such will include discussions with U.S.

Forest Service staff and local stakeholders associated with each forest unit. Five other National Forests are now developing similar indicators nation-wide.

Eventually, the USDA Forest Service hopes to implement the use of local unit criteria and indicators on forest land units over a three-year period to demonstrate the practicality and value of forest monitoring systems focused on sustainability. This effort will involve applying the criteria through on-the-ground monitoring and, thereby, evaluating sustainability to improve forest management. The effectiveness and efficiency (i.e., costs) associated with implementing this scheme could then be evaluated for broader application within the Lake Superior basin.

Alternatively, a number of local economic development organizations, such as Northern Initiatives in the central Upper Peninsula of Michigan, have previously sought public funding to examine and improve upon the “Best Management Practices” of small forest contractors who work in the woods for government agencies and private industry. It may be possible to partner with such organizations so as to improve their chances of obtaining grants aimed at securing the sustainability of timber industries while protecting the larger resources provided by the forests in the basin.

9.5.1.4 Reviewing the Status of Sustainability Education

The best opportunity to promote sustainability is to educate young people about the environment and our relationship to it. Unfortunately, previous nation-wide studies of environmental curricula suggest that, although today’s students know a lot more about the environment that their predecessors, such knowledge is often fragmented. Certainly, a lot of education occurs in the informal settings of family and community life but, if we want to optimize the use of our financial resources, we should focus on what gets taught in primary and secondary schools. Hence, the intent of this project is to gain a better picture of the extent to which sustainability principles are currently being incorporated into environmental education programs in the basin. This project will collect information from educational centers (e.g., the Lake Superior Center, Wolf Ridge Environmental Learning Center), Offices of Environmental Assistance, and as many schools and science teachers as possible within the region regarding what is being taught at present. Based on this information, programs can be compared and evaluated with an eye toward determining if existing programs are equipping citizens with the information and understanding that they need to make informed choices about lifestyle issues that affect sustainability. Appropriate reports will be drafted and disseminated across the study area.

To promote the goals of the Binational Program, we believe that an assessment of what is currently being taught about sustainability will allow us to provide teachers with an integrated package of educational resources tied to the sustainability theme. There are a variety of ways we will proceed to leverage enriched educational opportunities in our schools. The U.S. Department of Education, the President's Council on Sustainability, and various State agencies have developed compendia of environmental education programs focusing on the sustainability issue that can be given a Lake Superior "spin" and shared with teachers in the basin through partnership agreements. Such will involve assembling a relatively digestible educational program dealing with sustainability issues (stratified for various educational levels), perhaps even linked to annual events (e.g., Earth Day, Arbor Day), to be sent to educators in the watershed. Additionally, through a variety of means (e.g., a dedicated page on the Binational Program's web site), we will also alert teachers to more specific sources of information (e.g., elements of environmental design, regional land-use planning) housed at the Federal, Provincial, and/or State level.

In concert with more formal educational venues, the Lake Superior Binational Forum has successfully developed a number of initiatives to enhance awareness among citizens in the basin to the importance of the Lake Superior Binational Program. Additional areas of interest include regional consumption habits, the import/export and life-cycle of commodities, ways in which local industries are adopting innovative practices, and awareness about the connection between consumption and the exploitation of resources and humans in other parts of the world in order to satisfy local needs. These education programs also aim to enhance awareness about the connection between consumption and the exploitation of resources and humans in other parts of the world in order to satisfy local needs.

9.5.2 "Levers" to Promote Basin-wide Sustainability

The following three projects are intended to act as levers for changing the status of sustainability in the Lake Superior basin. Specifically, they will focus on improving stakeholders' understandings of sustainable economics, the management of water resources, and the marketing of conservation programs. In a number of ways, each complements the wide range of community-based programs already underway throughout the watershed that have not been initiated by the Binational Program (e.g., the Sturgeon/Otter and Chocolay watershed projects in Michigan). In addition, each lever-oriented project includes a monitoring component, which allows us to gauge the effectiveness of our attempts to alter lifestyles and business practices.

9.5.2.1 Communicating Economic Values and Teaching the Value of Economic Instruments

This project focuses on two separate dimensions. First, we will identify and assess the utility of specific "economic instruments" (e.g., user fees, pollution charges, permit trading programs, performance bonds) applicable to various business sectors located in the Lake Superior basin. Market-based mechanisms and other incentives for environmental management have been touted at all levels of government as offering opportunities to encourage resource protection and conservation. However, their utility may be different in a northern watershed like the Lake Superior basin than in other regions of Canada and the United States. Consequently, some effort is required to identify which specific tools might have applicability in the Lake Superior LaMP, and to share this information with to basin residents. Second, we want to demonstrate and publicize the economic importance of natural resource systems in the basin for resource decision-making. Some effort has been expended over the last decade to "monetize" the value of Great Lakes basin resources (e.g., wetlands, fisheries, water supply, and biodiversity). This portion of the project will generate approximations of the economic value of resources in the Lake Superior ecosystem. Based on existing literature, we will compile current monetary estimates of Great Lakes ecosystem values, and then extrapolate those values to the Lake Superior basin. Along with information regarding various economic instruments, these estimates will be disseminated to industry and civic decision-makers by way of sector-specific direct mailings. Emphasis will be placed upon demonstrating the relationship between values for Lake Superior basin resources, their management via market-based incentives for conservation and pollution protection, and the long-term sustainability of regional economies.

To evaluate the worth of this project, we will survey stakeholders in the basin after they have received information concerning economic values and instruments. We will probe whether businesses and local governments change the way they manage revenue streams and profit margins based on the information we provide. By collaborating with organizations such as the Upper Lakes Environmental Resource Network (ULERN) in Canada and the U.S. EPA Office of Policy and Innovation, we should be able to tailor subsequent approaches to encouraging changes in stakeholders' reinvestment in natural capital and the use of advanced technology to support an environmentally benign economy in the region.

9.5.2.2 Promoting Water Conservation

Efficient water use is an important component of sustainability. This project builds on the work of Thunder Bay 2002 (now EcoSuperior) and the City of Thunder Bay by continuing to expand on a number of local initiatives. These include the toilet replacement rebate program, which provides $125 towards the purchase of an ultra low flush toilet in residential, commercial and institutional buildings, and water audits that involve on-site assessments and recommendations for reducing water use (in addition to energy and solid waste use) in all sectors. These programs, in addition to the existing "downspout disconnection" program and the rain barrel promotion, which offers rain barrels to encourage the reuse of rainwater from rooftops, provides the elements of a comprehensive water conservation program. Newsletters, fact sheets and brochures will be disseminated to encourage local and adjacent communities to adopt water efficient practices.

Program effectiveness will be gauged by indicators such as the number of water audits completed, the number of replaced and/or retrofitted water-using fixtures, the adoption downspout disconnections and rain barrel installations, augmented where possible by actual water and energy bill savings. Ultimately, the main indicator of progress will be the reduction in municipal water pumpage and use, recognizing that many different factors affect total water pumpage. This project involves collaboration with a number of agencies, businesses, groups and funding organizations. Dissemination of the Thunder Bay experience to the remainder of the Lake Superior basin is a fundamental element of this project.

A related initiative focuses on the importance of developing and implementing pollution prevention planning and procedures in the pulp and paper sector. Water and energy are used in large quantities in this industry. The Cascade Fine Papers (formerly Provincial Papers) mill in Thunder Bay has expressed interest in partnering with EcoSuperior to develop efficiencies related to water and energy use at the mill. This project will examine core mill processes to identify operations where water and energy efficiencies could be most successfully implemented.

This would be followed by implementation of those measures determined to be practically and economically feasible. Successes would be disseminated to other mills.

9.5.2.3 Marketing Waste Reduction and Energy Efficiency

A major component of advancing sustainability in the Lake Superior basin involves explaining pollution prevention measures to those located in the watershed. Currently, a wide array of state, federal, and provincial initiatives has been established to assist the private sector in reducing waste and conserving energy. Occasionally, agencies participating in the Binational Program and the Lake Superior Forum have hosted workshops dealing with waste reduction and energy efficiency. The programs sponsored by federal (e.g., U.S. EPA's ENERGY STAR program) and state agencies (e.g., Michigan's Business Pollution Prevention Partnership sponsored by the Department of Environmental Quality) most likely find their greatest marketability in areas of heavy industry and metropolitan populations that are quite unlike the Lake Superior catchment.

Large industries in the basin likely understand the range of assistance that is open to them, given their compliance with governmental regulations or the institutionalization of accrediting regimes (e.g., the ISO process).

The key to successful pollution prevention, especially among small businesses, is a community-based approach. WLSSD, EcoSuperior, Superior WI and many other communities have been successful in pollution prevention because local community staff work with businesses and public facilities.

9.5.2.4 Co-Host Sustainability Forums

In addition to the community awareness review and development project described above, a number of other general or sector-specific sustainability workshops could be hosted in partnership with local organizations or Public Advisory Committees tied to Remedial Action Plans for formally designated "Areas of Concern" in the basin. In this case, the focus of the workshops would be adapted to each location. Some workshops would deal with fairly tangible issues such as managing urban encroachment, storm water permitting requirements, or (in co-operation with established U.S. EPA Superfund plans) to discuss the potential for including habitat restoration as part of site remediation efforts. Other forums might focus on more abstract concerns. For example, research suggests that forested areas in the Lake Superior basin do not represent significant or salient components in citizens' descriptions of where they live, what activities they engage in, and what their preferences are for valued lifestyles. If this is generally the case, it is important to alter perceptions so as to enfranchise the public in the process of demanding that forestry practices adopt the principles of sustainability. By drawing upon the community leaders and local expertise found in various basin communities, such forums will help to generate further ownership in the broader program of the LaMP. Finally, within the partnerships constituting the Lake Superior Binational Program, groups of citizens in the basin are also interested in evaluating actions taken by industries and communities to achieve sustainability. Essentially, this approach to measuring progress uses a "Report Card" format to identify achievements and areas in which progress is lacking.

9.5.2.5 Engage Media Campaigns for Public Outreach

As most of us recognize, the general public remains unaware not only of the Binational Program, but also of the concept of "sustainability." Thus, a primary objective is to increase public awareness of (a) what sustainability means in the context of basin life, (b) how individuals and communities can contribute to the overall goal of sustaining a valued quality of life in the watershed, and (c) ways the Developing Sustainability Committee can facilitate long-term sustainability. Of course, it is a marketing challenge to communicate a simple, unified message that embraces the ecological, social, and economic dimensions inherent in the concept of sustainability. In some respects, what is called for is akin to a "50 Things You Can Do To Sustain the Basin" communication campaign patterned after a brochure now being distributed by the Lake Superior Forum.

The public-at-large holds the key to sustainability, rather than the governments. The Binational Forum has argued that the general public has the responsibility to seek a standard of living that fully integrates conservation practices, to accept that the true cost of material consumption must include the replacement or loss or resources and the management of pollution, and to recognize that tax policies should take into account differences between resource conservers and consumers.

A variety of media can be employed to hasten changes such as those suggested above. Initially, we may produce a brochure featuring the Binational Program's Vision Statement, a simple definition of sustainability, easily accomplished suggestions for behavior, and references for further information. This brochure would be made available to the public at a variety of venues around the basin (e.g., visitor centers, service-oriented businesses, government offices). Follow-up projects would include the use of alternative media focusing on the same basic themes, perhaps patterned after the public involvement strategies being adopted for publicizing LaMP 2000 after its release.

9.5.2.6 Building Community Capacity

There is increasing evidence that grassroots initiatives are at the heart of successful gains in sustainable development. For example, consider the role of communities in the creation of "new wealth" through self-reliance. New wealth is created when an economy can produce more using the same or fewer amounts of energy and the same or a fewer number of resources - stretching existing resources further through conservation and recycling. In this way, economic growth is tied to ecological sustainability. Communities can also play a critical role in land-use planning, import replacement and maximizing the multiplier effect of economic and social initiatives.

In the coming years it will be imperative that we continue to enhance the ability of communities to live sustainably on a day-to-day basis. For example, we hope to work with U.S. EPA regarding current Superfund commitments to enhance local capacity for responding to emergencies, preventing further releases of toxic materials into the basin ecosystem, and providing outreach and education on "brownfields" redevelopment to local land use planners and decision makers. Not only will such initiatives reduce the need to secure broad-scale funding through the Binational Program, but they will also cultivate local autonomy.

We believe that one of the most efficient mechanisms for building community capacity will come through the widespread accessing of the Binational Program's web page or e-mail list serves such as the "Sustainable Communities Network" (e-mail: mnscn@mr.net). Thus, we hope to highlight local success stories on the Binational Program's site that can be emulated by others around the basin, as well as orient the broader public to selected sources on the world-wide web that focus on rural sustainable development. As an illustration, the following two web sites may be of particular use:

- "Online National Library for the Environment" (http://www.cnie.org), managed by the Committee for the National Institute for the Environment.

- "Sustainable Development - ONLINE" (http://susdev.eurofound.ie), managed by the European Foundation for the Improvement of Living and Working Conditions (contains more than 300 sites, including excellent examples of initiatives from Finland).

In addition, a variety of other sites may provide citizens with the resources necessary to change lifestyles and promote sustainability in the Lake Superior basin:

- Corporations and Sustainable Development (http://www.betterworld.com)
- Center of Excellence for Sustainable Development (http://www.sustainable.doe.gov)
- The Citizens Network for Sustainable Development (http://www.citnet.org)
- Smart Growth Network (http://www.sustainable.org)
- Communities by Choice (http://www.communities-by-choice.org)
- Sustainable America (http://www.sustainableamerica.org)
- Sustainable Development Information System (http://www.sdinfo.gc.ca/SDinfo/en/default.htm)
- International Institute for Sustainable Development (http://iisd.ca)
- Canadian Sustainability Report (http://www.sustreport.org)
- State of the Lakes Ecosystem Conference (SOLEC) sustainability indicators (http://www.epa.gov/glindicator or http://www.cciw.ca/solec/)
- Minnesota's Interactive Directory of Environmental Education Resources (http://www.seek.state.mn.us/)
- New Road Map Foundation (http://www.newroadmap.org)
- Simple Living Network (http://www.simpleliving.net)
- Hennepin County (MN) Indicators of Community Sustainability (http://www.co.hennepin.mn.us/opd/opd.htm)
- Fostering Sustainable Behavior (http://www.cbsm.com)
- Minnesota Sustainable Development Initiative (http://www.mnplan,state.mn.us/SDI/index.html)
- World Resources Institute (http://www.wri.org)

9.5.3 Promoting Sustainability through Partnerships

Recognizing that partnerships with other programs could improve funding opportunities, there are a number of new sustainability projects on the horizon. For example:

- The Natural Resources Research Institute at the University of Minnesota - Duluth has determined that as much as 80 percent of the phosphorus loadings in basin watersheds can be attributed to road runoff, consisting mostly of fertilizer leaching from the maintenance of lawns. With the establishment of new zoning regulations and the installation of municipal sewer systems (driven by developers servicing in-basin migrants and the growth in vacation homes), more pressure will be exerted on the ecosystem by a reduction in buffers around riparian areas. To compensate for the potential threat of additional phosphorus loadings to the system, we want to promote the voluntary use of hardy native groundcovers that require little fertilization. To this end, The Central Lake Superior Land Conservancy has secured a Grant from the Great Lakes National Programs Office to establish demonstration sites for the use of conservation easements and native flora as riparian buffers.

- Across the Great Lakes basin, several existing or planned monitoring regimes address sustainability. For example, the SOLEC process has developed an indicator to assess land-use and stewardship based on an integrated collection of targets and indicators. The Great Lakes Protocol Workgroup of U.S. EPA has sought to establish consensus among the lake states for assessing the quality and quantity of drinking water sources in the region. Furthermore, the Terrestrial Wildlife Committee of the Lake Superior Work Group has suggested incorporating aspects of the Montreal Process and local land unit indicators for sustainable development. It will be useful to compare and standardize these indicators to optimize the use of agency resources directed at the sustainability initiative since, to date, we have attacked the problem only in a piecemeal fashion (e.g., as was attempted in 1998 when the SOLEC and EPO indicators were compared).

- Urban sprawl is one of the major contributors to the loss of biodiversity. Although urban sprawl is not as prevalent in the Lake Superior basin as elsewhere, cities such as Duluth, Marquette, and Thunder Bay have begun fragment in their hinterlands; as residents relocate in “fringe” areas, services follow, contributing to increases in energy consumption, erosion caused by run off from impervious surfaces, and habitat destruction. Currently, we know little about what prompts people to move out of cities or how to convince citizens that denser populations are in their long-term best interests. To complement existing efforts to control urban sprawl (e.g., the development of “Smart Growth” criteria for urban expansion being promulgated in Minnesota), we have partnered with the U.S.D.A. Forest Service’s North Central Experiment Forest Station to suggest avenues for persuading those living in the basin to remain closer to urban settings. Recently conducted studies suggest that residents’ desires to locate in the urban fringe or rural areas of the basin are born of economic conditions followed by a desire for the penetration of municipal services into previously unfragmented countryside.

- In recent years there has been a substantial growth in the number of watershed management projects in the basin. Most of the time, these programs focus on water quality, aquatic habitat restoration, and sedimentation reduction. Occasionally, a number of existing and emerging watershed projects have banded together and have secured funding to address broader issues associated with sustainability (e.g., the Central Lake Superior Watershed Partnership). The Developing Sustainability Committee may wish to craft a compendium of such watershed management programs, demonstrate how various programs can work within an evolving regulatory context (e.g., the National Pollution Discharge System will soon be requiring that best management practices be adopted to control storm water drainage), and encourage the systematic modification of existing programs in light of sustainability principles. For example, some have suggested that we investigate the possibility of providing municipalities with financial assistance (from either state or federal sources) so as to purchase, rehabilitate, and further protect degraded sections of urban watercourses. Additionally, there are several watersheds in the basin (most notably on the North Shore of Lake Superior) that, due to their remoteness and relative lack of adjacent development, do not currently have citizens cooperating to restore and preserve the resource. This project might also attempt to cultivate awareness among citizens in those watersheds of the benefits of watershed management plans.

- Some members of the Lake Superior Binational Forum have advocated an ambitious option for both safeguarding water quality and furthering economic productivity in the basin that embodies the practices of industrial ecology, full cost accounting and life cycle analysis, and a commitment to the virtual elimination of bioaccumulative toxins. The proposal is twofold: First, to create a project and investment fund to finance “green" industrial and business start-ups in the basin. Such could, over time, have a substantial impact on economic development in the basin while promoting the practical use of sustainable technology. Second, an attempt would be made in Canada and the United States to create two “Eco-Industrial Parks,” perhaps in a partnership with Cornell University’s “Work and the Environment” initiative. A number of attractive possibilities are presented by this emphasis including the use of existing brownfield locations and “renaissance zones,” establishing co-generation relationships with the relevant local utilities, extensive recycling and reuse of waste, reliance on local employees, and sustainable contributions to local economic infrastructures. In either case, the Developing Sustainability Committee could be drawn upon to help the Forum in slowly developing guidelines for assisting communities in search of “greener” economies.

Chapter 10

Aquatic Nuisance Species

Zebra Mussel, Detroit River
Photograph by: Center for Great Lakes and Aquatic Sciences

Lake Superior Lakewide Management Plan
2000

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EXECUTIVE SUMMARY

An increasing concern for environmental policy makers in the Great Lakes region is the invasion of aquatic habitats by nonindigenous (non-native) species. Nonindigenous species, also known as non-native and exotic species, are those that do not naturally exist in an environment and have been introduced by human activity, either intentionally or unintentionally. Aquatic nuisance species (ANS) in the Great Lakes have both ecological and economic impacts. ANS have seriously altered and disrupted Great Lakes ecosystems, due to a lack of co-evolved parasites and predators to keep their populations under control. The ANS have the ability to out-compete native species for food and habitat, and in the most severe cases, to displace native species entirely.

The ANS that are currently the greatest threat to the integrity of the Lake Superior ecosystem include alewife, Eurasian water milfoil, purple loosestrife, rainbow smelt, round goby, ruffe, sea lamprey and zebra mussel. A discussion of each of these ANS threats is provided along with a brief discussion of noxious terrestrial invasive species.

Various federal programs have been implemented in an attempt to check the negative impact that nonindigenous species are having on the Great Lakes. Foremost is the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA), which provides federal legislative support for programs aimed at ANS prevention and control. Under the NANPCA, the Great Lakes became the first area where ballast water regulations were imposed. A variety of other programs to help prevent and control the spread of ANS have been established under the authority of the NANPCA, including the Aquatic Nuisance Species Task Force, Comprehensive State Management Plans and the Great Lakes Panel on Aquatic Nuisance Species. In 1996, the NANPCA was reauthorized through the National Invasive Species Act (NISA). President Clinton reinforced the need to stop the further introduction of nonindigenous species when he signed the Invasive Species Executive Order on Feb. 3, 1999.

Other programs implemented to help stem the invasion by nonindigenous species include the Great Lakes Action Plan for the Prevention and Control of Aquatic Nuisance Species, model guidance, The Great Lakes Ballast Water Technology Demonstration Project (GLBTDP), U.S. Coast Guard programs, Canadian Coast Guard programs, tribal programs, and Canadian programs. In an effort to have ballast water more stringently regulated by the U.S. government, the Pacific Environmental Advocacy Center (PEAC) filed a petition with EPA requesting that EPA repeal its exemption of ballast water from National Pollutant Discharge Elimination System (NPDES) regulation under the Clean Water Act (CWA).

The management activities of ANS have four distinct components: educational outreach, detection and monitoring efforts, prevention activities and control activities. Within each of these components are a variety of measures that can and/or should be taken. Of particular concern is the need to design and implement effective ballast management programs and resolution of the “no ballast on board” (NOBOB) issue.

Experts disagree about the relative importance of prevention and control. Effective control in aquatic systems is often impossible, but the impacts of ANS merit an attempt. At least partial success has been achieved in control programs with the sea lamprey, ruffe, and purple loosestrife. Everyone agrees prevention is best, because once a species invades a new habitat, it is virtually impossible to eradicate it from that environment. This need for adequate prevention explains why such an emphasis is placed on restricting and regulating ballast water discharges in an attempt to stop further introductions of ANS.

Finally, additional efforts need to be explored and implemented to stop further introduction and spread of nonindigenous species. Examples of such efforts are suggested in the policy recommendations and needed actions section and include the need for better identification of possible future invaders, the need to encourage interjurisdictional cooperation and information sharing, the necessity to devise new technology to deal with the threat of ANS, and the need to improve ballast water management.

10.0 ABOUT THIS CHAPTER

This section was developed primarily from the draft document entitled *Briefing Paper for Great Lakes Nonindigenous Invasive Species Workshop* for the October 1999 meeting, and also reflects a number of comments received from expert reviewers.

10.1 PROBLEM STATEMENT

Invasion of aquatic habitats by nonindigenous (non-native) species has become an increasing concern for environmental policy makers in the Great Lakes region. Nonindigenous species, also known as non-native and exotic species, are those that do not naturally exist in an environment and have been introduced by human activity, either intentionally or unintentionally. Some nonindigenous species are disruptive to the new aquatic environment because they lack natural predators to curtail their expansion. These species are referred to in this section as aquatic nuisance species (ANS). ANS compete with native species for food, territory and breeding areas and often end up threatening the existence of the native species. For example, the Eurasian ruffe colonized the nearshore waters of western Lake Superior in the late 1980s (Pratt and others 1992), and became very abundant in this favorable habitat, raising concerns about its competition with native species (Ruffe Task Force 1992, Bronte and others 1998). Zebra mussels and round gobies have caused pervasive impacts in the other Great Lakes and may yet have serious impacts in Lake Superior. In the Great Lakes ecosystem, this biological form of pollution is considered by some to be just as threatening to environmental health as is pollution caused by chemical contaminants. Therefore, ANS deserve the attention and resources needed to address the problem before further harm is done.

Since the 1800s, more than 139 nonindigenous aquatic organisms have become established in the Great Lakes, including 25 species of fish (Mills and others 1993). Of the 94 fish species known to inhabit Lake Superior and its tributaries, 18 are nonindigenous (U.S. Fish and Wildlife Service [USFWS] 1995). Approximately 10 percent of the nonindigenous species introduced into the Great Lakes can be classified as nuisance species; all have had significant impacts, both economic and ecological. Unintentional introductions of these species into the Great Lakes have occurred primarily through the transport of ballast water carried in ships engaging in international trade, but other practices, such as the building of canal systems within the Great Lakes basin, fish stocking practices, angling, recreational boating and aquarium releases have also contributed to the problem. The rate of introductions has increased; nearly a third of the nonindigenous organisms found in the Great Lakes have been introduced since the opening of the St. Lawrence Seaway in 1959. Once introduced to the Great Lakes, nonindigenous species spread inland, frequently by way of barges, recreational watercraft, bait buckets, fish stocking, and other human-assisted transport mechanisms. The spread of species between ecosystems is usually hampered by natural barriers such as the open ocean, different salinity levels, and the inability of organisms to reach hospitable ecosystems on their own. However, shipping allows many organisms to bypass these natural barriers through the transportation of nonindigenous species in the ballast water of seagoing vessels involved in international trade. In summary, shipping disrupts the customary checks and balances in place to prevent introductions of nonindigenous species and the subsequent degradation of ecosystems (U.S. Coast Guard [USCG] 1999).

One of the impacts of an established nonindigenous species is the promotion of instability and unpredictability in stable ecosystems, and the loss of diversity in biotic communities (Mills and others 1993). ANS can also be responsible for extinctions of native species and ecological degradation of the Great Lakes basin.

ANS have had, and continue to have significant economic effects on the commercial fishing industry, agriculture, tourism, sport fishing, recreation, utilities and other industries. The U.S. Office of Technology Assessment (OTA) delivered a 1993 Report to Congress entitled *Harmful Non-Indigenous Species in the United States*, which attempted to measure the economic impact of nonindigenous plants, animals and microbes on aquatic environments. The report assessed over 4,500 non-indigenous nuisance species, including 2,000 plants, 2,000 insects, 142 terrestrial invertebrates, 91 mollusks and 70 species of fish. Economic costs are hard to accurately estimate since no federal agency comprehensively compiles such statistics. Ecological damage and other nonmarket impacts were not assessed; the report stated, however, that even when such losses were estimated, cost assessments of losses tended to be underestimated (OTA 1993).

Another estimate of economic losses due to nonindigenous species was made in a 1999 study by Pimental and others from Cornell University. The study documented over 50,000 nonindigenous species in the U.S. with an estimated annual economic cost of $138 billion (Pimental and others 1999). Included among the cost estimates were control costs, property value damage, health costs and various other expenses. Pimental and others also indicated that if monetary values could be assigned for ecological losses, the economic cost would be much higher than the $138 billion estimated. Given the high ecological and economic costs to the Great Lakes, heightened vigilance is necessary for the prevention and control of ANS.

10.2 STATUS AND CURRENT CONDITIONS OF AQUATIC NUISANCE SPECIES

In the Great Lakes basin there are a number of ANS believed to constitute the greatest threat to native species. As a result, these ANS have been targeted for initial action. Lake Superior related information has been included in this section to indicate the threat to this particular ecosystem. The ANS discussed below (both flora and fauna) are listed in alphabetical order and are not prioritized in terms of potential or known impacts.

Alewife

Alewife (*Alosa pseudoharengus*), a fish closely related to the Atlantic herring (*Clupea harengus harengus*), invaded the Great Lakes around 1953 after the building of the canal systems. Alewives are known to prey upon the pelagic larvae of native fish species and to suppress recruitment of those species. While they were once a serious threat to native fish and recreation, this threat was mitigated with the introduction of nonindigenous salmonid species into the Great Lakes as a biological control for alewife populations. However, consumption of alewives by the salmonid species has had an unintended counter-effect on these predators, since alewives are also implicated as a putative causal agent for early mortality syndrome of salmonine fishes, which results in elevated mortality of newly-hatched salmonine larvae as a result of thiamine deficiency. Alewives have a high concentration of the enzyme thiaminase, which degrades thiamine, and a diet rich in alewives is believed to lower thiamine levels in eggs of female salmonine predators.

Viewpoints on the effects of alewives on native fishes differ among biologists, but evidence does at least show the potential for negative interactions in both the upper lakes and lower lakes. Alewife intolerance to cold temperature (i.e., moderate to harsh winters) has been correlated with improved recruitment of native percids in Lake Erie. There have been efforts in recent years to protect alewife populations through control of commercial fisheries and reduced salmon stocking. Alewives are still a threat to native species (nonindigenous species too) because they have been found to prey on eggs and fry of lake trout, compete for food, and most importantly contain thiaminase, which, as noted, has been linked to early mortality syndrome in their predators such as lake trout, walleye, and salmon (Eshenroder and others in Great Lakes Fishery Commission Technical Report 64). While the alewives are not currently a major threat in Lake Superior, the species is poised to enter the Lake Superior ecosystem from other Great Lakes if its progress is not checked.

Eurasian Watermilfoil

Eurasian watermilfoil (*Myriophyllum spicatum*) forms masses of vegetation in nutrient-rich lakes (usually inland). It crowds out native aquatic vegetation and interferes with water recreation. It is unclear at this point how much of a threat the Eurasian watermilfoil poses to the Lake Superior ecosystem.

Purple Loosestrife

Purple loosestrife (*Lythrum salicaria*) is a plant native to Europe that was first brought to North America in the early 1800s. Purple loosestrife is now found throughout much of the United States and Canada. It has invaded wetland areas, where it has a competitive advantage over native plant species, and has formed habitats that are unsuitable for native wetland animals. Control measures used on purple loosestrife include physical removal, chemical treatment, and biological control through introduction of natural predators, European beetles and weevils.

Rainbow Smelt

Rainbow smelt *(Osmerus mordax),* native to the Atlantic coast, entered Lake Superior around 1930. Rainbow smelt populations grew rapidly during the 1950s and 1960s, and became the dominant prey species for lake trout in Lake Superior (Dryer and others 1965, Conner and others 1993). Rainbow smelt became the principal forage fish for lake trout and other top predators and have been implicated as a competitor for the native lake herring, whose populations collapsed during the buildup of the smelt population. The rainbow smelt population continued to grow until the late 1970s and then declined greatly due to heavy predation by trout and salmon, reaching all-time low levels of abundance in the early 1980s. Rainbow smelt prey upon the larvae of native fish and eat a diet that broadly overlaps that of other native cisco species. Smelt are the preferred food for predator fish, and have profoundly changed the flow of energy through the Lake Superior fish community. Rainbow smelt also contain thiaminase (about half as much as alewives) and therefore have a negative impact on the survival rate of newly-hatched salmonine larvae. Fishery management agencies in the Lake Superior basin have agreed that rainbow smelt is an undesirable species that should not be protected from fishing.

Round Goby

The round goby (*Neogobius melanostomus*) is a small, bottom-dwelling, soft-bodied fish. It is native to the Black and Caspian Seas, was first detected in the St. Clair River in 1990, and by 1995 had spread to four of the five Great Lakes. The round goby was discovered in Lake Superior in the St. Louis River Estuary in 1995. It is believed that round gobies were introduced to the Great Lakes through ballast water transfer. The goby is currently poised to enter almost half the United States through connected waterways unless its progress can be halted. The round goby is currently found 44 miles downstream in the Illinois Waterway, which connects to the Mississippi River.

Round gobies are particularly threatening because they are aggressive, territorial, competitive for food, spawning, and shelter areas, highly tolerant of a variety of environmental conditions, feed on eggs and fry of native fish, and have a large body size compared to similar bottom-dwelling fish species. On the beneficial side, gobies eat large quantities of small zebra mussels, up to 78 mussels per day in laboratory settings. Because gobies eat zebra mussels and in turn are eaten by many piscivorous fishes, they provide a conduit from mussel tissue to fish tissue that was previously less available in a goby-free environment. Contaminant transfer from zebra mussels to highly-valued fish species is an issue. Research is underway to investigate the severity of this problem.

Ruffe

The ruffe (*Gymnocephalus cernuus*), a small perch-like Eurasian fish, was first detected in the estuary of the St. Louis River in western Lake Superior in 1986 and became very abundant in the favorable habitat of the nearshore waters, raising concerns about competition with native species (Ruffe Task Force 1992, Bronte and others 1998). It is believed to have been transported there in the ballast water of seagoing vessels, as Duluth is a major port on Lake Superior. By 1991, the ruffe was the most abundant species in the St. Louis River estuary. The ruffe is also now found in Lake Huron at Alpena Harbor, Michigan, very likely the result of transport in ballast water of interlake shipping. The Great Lakes Fishery Commission estimates the European ruffe could cause annual losses of $105 million annually if is not controlled. A control program for ruffe was approved in 1995 and has been successful in delaying the spread of ruffe in the Great Lakes and inland waters.

Sea Lamprey

The sea lamprey (*Petromyzon marinus*) is an eel-like, jawless fish that attaches itself to the body of a fish and sucks blood and tissue from the wound. The lamprey is native to coastal regions on both sides of the Atlantic and was first noticed in Lake Ontario in the 1830s. Originally, Niagara Falls served as a natural barrier to keep sea lampreys out of the upper Great Lakes. However, when the Welland Canal was constructed in 1829 for the shipping industry, a new route for sea lampreys was opened and the invasion of the upper Great Lakes began.

In 1921 the lamprey was discovered in Lake Erie, in 1936 in Lake Michigan, in 1937 in Lake Huron and finally in Lake Superior in 1938. The sea lamprey is considered the most devastating of all ANS to have infested the Great Lakes. A subsequent explosion in the sea lamprey population caused extinction in lake trout in all the Great Lakes but Lake Superior. It is only through control and restocking activities that lake trout populations have recovered. Even today, the Fishery Commission has declared that more fish are taken by sea lamprey every year than by commercial and sport fishing combined. An international control program under the Great Lakes Fishery Commission has successfully suppressed sea lamprey populations since about 1960. This control program is the oldest control program in existence in the U.S., and yet all efforts have still been unable to eradicate the species from the Great Lakes ecosystem.

Zebra Mussel

The zebra mussel (*Dreissena polymorpha*) is native to the Caspian Sea region and quickly spread throughout Europe before the Industrial Revolution. It is believed to have entered the Great Lakes region in 1985 or 1986 through ballast water discharge. By 1989, zebra mussels could be found in all of the Great Lakes, as well as many inland lakes. Under the right conditions, zebra mussels reproduce quickly, are very prolific, and are very tolerant to a wide range of environmental conditions. Environmental conditions in the Lake Superior basin have generally prevented reproduction by zebra mussels, though mild weather in recent years has apparently allowed reproduction to occur in the St. Louis Estuary.

Zebra mussels compete with native species for phytoplankton and zooplankton, are believed to contribute to the cycling of some contaminants, fundamentally alter the habitat and food webs, and are harmful toward native mussels to the extent that they kill native mussels by encrusting their shell so heavily that the native species cannot open to feed or breathe. Beyond their ecological effects, zebra mussels also create serious financial costs for facilities that draw water from the Great Lakes by clogging water intake systems. Although various methods are being explored, no effective means of control in natural aquatic systems has yet been found for zebra mussels in the Great Lakes.

Other Species

Several other species of concern have colonized in Lake Superior and/or tributaries. A summary of these species has been compiled for this chapter by Douglas A. Jensen, Exotic Species Information Center Coordinator at the University of Minnesota Sea Grant Program, Duluth and is listed in Addendum 10-A at the end of this chapter. For completeness, the previously mentioned species have also been included in the table.

10.3 TERRESTRIAL SPECIES

Even though the focus of this chapter is aquatic nuisance species, it bears mentioning that there are a number of terrestrial nuisance species that are threatening the biodiversity of the Lake Superior basin. These species include the following, in part excerpted from the article, *Weeds Gone Wild* by Jay Rendall:

Exotic Buckthorns

Exotic buckthorn *(Rhamnus cathartica* and *R. frangula)* has invaded plant communities from state parks to back yards. European or common buckthorn invades woodlands. Glossy or columnar alder-buckthorn is generally found on moist soils.

Exotic Honeysuckles

Exotic honeysuckles *(Lonicera tatarica, L. morrowii, L. maackii,* and the hybrid *L.* x *bella)* have been used as ornamentals for decades. Birds carry their seeds from formal landscapes to natural habitats, including grasslands, marshes, and woodlands. Once established, often with European buckthorn, honeysuckle can dominate the understory of woodlands.

Garlic-mustard

Garlic-mustard *(Alliaria petiolata)* spreads and dominates the ground flora in forests, replacing native woodland plants. Seedlings of this biennial herb germinate in early spring and by midsummer form a cluster or rosette of three or four leaves. In the spring of its second year, it flowers, sets seed, then dies. Floodwaters, wildlife, people's footwear, and off-road vehicles carry seeds to new sites. Management methods include hand removal, herbicide treatments, and repeated burning, though none can control large infestations. A long-term control using biological agents is being sought.

Leafy spurge

Leafy spurge *(Euphorbia esula)* is a plant that has roots that can extend 35 feet, grows through asphalt, and flings its seeds 15 feet. It invades prairies, roadsides, and pastures. Its deep root system enables it to survive dry conditions and resprout even after the foliage is destroyed. Control usually combines use of herbicides, prescribed fire, and mowing. Insects for biological control have been released at several hundred sites in the state of Minnesota by the U.S. and Minnesota departments of agriculture.

Reed canary-grass

European and cultivated strains of reed canary-grass *(Phalaris arundinacea)* were originally introduced as forage. This widely planted grass has also been used to establish cover on streambanks and wetland projects. Native plant populations are excluded after this species invades.

Spotted Knapweed

Spotted knapweed *(Centaurea maculosa* or *C. biebersteinii)* probably arrived here in alfalfa or hay seed from Europe and Asia. It reproduces solely by seed. Dry prairies, oak and pine barrens, and sandy ridges are likely natural habitats. Chemical control can be fairly effective, but cost is prohibitive. The USDA is conducting a biological control program, involving a root-mining beetle, two root-mining moths, and a flower moth, which has produced varying levels of success. Two species of seed-head-attacking flies have reduced seed production by 95 percent in experiments.

Asian Longhorned Beetle

The Asian Longhorned Beetle (*Anoplophora glabripennis)* is native to China, and is a hardwood tree pest. It is believed to have been imported to the U.S. in untreated wood used for pallets and packing materials. It was first discovered in the U.S. in 1996, and in a Chicago neighborhood in 1998. These beetles spread rapidly from tree to tree, killing trees by boring deep holes in them. There is no known method of eradicating the beetles short of destroying the infested trees. Due to its recent introduction into the Great Lakes basin, the extent of potential damage due to this non-native nuisance beetle has not yet been assessed, although hundreds of trees have already been destroyed in the Chicago area.

Gypsy Moth

The gypsy moth *(Lymantria dispar)* is plain-looking insect that people would not notice if it were not for its caterpillar stage. A female moth lays a cluster of eggs (called an egg mass) on or near trees, and each egg mass can hatch up to a thousand tiny caterpillars with a ravenous appetite for leaves. They feed on over 500 species of trees and shrubs. Oaks and alder are preferred broad-leafed trees. Douglas fir and western hemlock are favorite needle trees. A new crop of hungry caterpillars is hatched each year, at the end of April or early in May. By the time they are ready to pupate into the moth stage, they can attain a length of 2-1/2 inches, which is 20 times their original size. The relentless chewing can strip entire stands of trees of all their leaves. People exposed to the caterpillars hate them. The caterpillars' strands of silk, their droppings, the shreds of wasted leaves, and their very bodies make homes, yards, parks, and playing areas unattractive.

Suppression means preventing buildup of damaging gypsy moth populations to protect recreation areas, forested communities, and high-value timber stands in the established infestation in the northeast. This work is carried out by state agencies with help from USDA’s Forest Service.

Hemlock Woolly Aphid

Introduced into the Pacific Northwest in the 1920s, the hemlock woolly aphid *(Adelges tsugae)* was first reported in eastern Virginia in the early 1950s. Since then it has spread primarily northeastward and now occurs as far north as Connecticut and Rhode Island. The primary host is hemlock, with spruce being a possible secondary (alternative) host.

Immature nymphs and adults damage trees by sucking sap from the twigs. The tree loses vigor and prematurely drops needles, to the point of defoliation, which may lead to death. If left uncontrolled, the aphid can kill a tree in a single year. When not at serious risk to the tree, presence of the dirty white globular masses of woolly puffs attached to the twigs or base of needles reduces the value of ornamentals.

Application of insecticides is currently recommended for controlling the hemlock woolly aphid. Tree fertilization can result in more damage, as aphid populations are known to flourish on such trees. It is believed that this species originally came from Japan. Currently, researchers are investigating the prospects of identifying and importing natural enemies for use against this pest.

Pine Shoot Beetle

The pine shoot beetle (*Tomicus piniperda*), a serious foreign pest of pines, was discovered at a Christmas-tree farm near Cleveland, Ohio in July 1992. A native of Europe, the beetle attacks new shoots of pine trees, stunting the growth of the tree. The USDA’s Animal and Plant Health Inspection Service (APHIS) has taken steps to prevent this insect from moving to major pine-tree production areas. APHIS, in cooperation with state officials, has quarantined 43 infested counties in Michigan, Indiana, Ohio, New York, Illinois, and Pennsylvania. Most of the beetle finds have been at Christmas-tree farms and pine-tree nurseries. The beetle prefers Scotch pine but will feed on most, if not all, species of pine. Although the beetle is slow moving, it could spread to other areas through the movement of Christmas trees, nursery stock, and pine logs.

In cooperation with state officials, APHIS is requiring the inspection of cut Christmas trees, pine nursery stock, and pine, logs, stumps, and lumber with bark attached before these regulated articles can move out of quarantined areas. Lumber and logs without bark attached are not regulated. Additionally, APHIS and cooperating officials are conducting wide-ranging detection surveys for the pest. State and federal scientists are working with the affected industries to develop appropriate control strategies.

10.4 CURRENT PROGRAMS AND INFORMATION GATHERING EFFORTS

The prevention and control of ANS has global implications that require policies and programs at various levels of government. This section provides a brief overview of the role of major programs and responsible agencies addressing ANS. For a more detailed explanation of the responsibilities of each agency, see the *Briefing Paper for Great Lakes Nonindigenous Invasive Species Workshop*.

Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA)

The NANPCA provides U.S. federal legislative support for programs aimed at ANS prevention and control. The Act was enacted by Congress in recognition of the fact that the ANS threat required well-coordinated research, monitoring and prevention programs at both the regional and national levels to be successful. Under the NANPCA, the Great Lakes region became the first area where ballast water regulations were imposed.

Aquatic Nuisance Species Task Force (ANS Task Force)

The ANS Task Force was established under Section 1201 of the 1990 NANPCA legislation and is an intergovernmental organization, made up of representatives from seven federal agencies, dedicated to the prevention and control of ANS and the implementation of the NANPCA. The main action of the ANS Task Force is the adoption of the cooperative ANS Program. The ANS Program seeks to prevent, detect, monitor, and control ANS.

National Invasive Species Act (NISA) of 1996

The NANPCA was reauthorized through the National Invasive Species Act of 1996. NISA expands the ballast management program to the national level, makes ballast water exchange mandatory in the Great Lakes and enhances other national monitoring, management, and control programs.

Executive Order on Invasive Species

President Clinton signed the Invasive Species Executive Order on February 3, 1999, to help complement and build upon existing federal authority to aid in the prevention and control of invasive species. President Clinton also proposed $28.8 million in support in the FY2000 budget. The Great Lakes region welcomes the attention the Executive Order has drawn to the effects of ANS on the region.

Great Lakes Panel on Aquatic Nuisance Species

Under the NANPCA, the ANS Task Force requested that the Great Lakes Panel on Aquatic Nuisance Species be convened in accordance with Section 1203 of the Act. The Great Lakes Panel also works for the prevention and control of ANS in the Great Lakes and is made up of representatives from the United States and Canada, as well as the eight Great Lakes states, Ontario, Quebec, and various regional and local agencies.

Comprehensive State Management Plans

Comprehensive State Management Plans are suggested for states seeking grants for ANS prevention and control under Section 1204 of NANPCA. Comprehensive State Management Plans are to identify management practices and measures for the prevention and control of ANS infestations in an environmentally sound manner. State management plans are submitted to the

ANS Task Force for approval. Upon approval, states are eligible for grant money upon the recommendation of the Task Force. Tribes and interstate plans are also eligible to receive grant money. Thus far, plans have been approved for the Great Lake states of Illinois, New York, Michigan, Ohio, and the St. Croix River basin; plans are currently being developed in Minnesota and Wisconsin.

Great Lakes Action Plan for the Prevention and Control of Aquatic Nuisance Species

The *Great Lakes Action Plan for the Prevention and Control of Aquatic Nuisance Species* is proposed for adoption by the governors of the Great Lakes states. It is an attempt to establish a formal policy agreement that articulates a vision for the Great Lakes basin. The Action Plan would be a good faith agreement among its signatories whose goal is the interjurisdictional cooperation and coordination of ANS prevention and control efforts.

Model Guidance

A plan has been developed by the Great Lakes Panel to help provide policy recommendations and needed actions for the Great Lakes community. The action is in the form of a model guidance, entitled *Legislation, Regulation and Policy for the Prevention and Control of Nonindigenous Aquatic Nuisance Species: Model Guidance for the Great Lakes Jurisdiction*. This model guidance is a toolkit from which states, provinces, tribal authorities, and local entities may select the regulatory tools that are best suited to address the problems in their infested watersheds. The goal of this guidance is to provide interjurisdictional consistency to laws, regulations and policies to be used for ANS prevention and control efforts. It is hoped that this multi-watershed, interjurisdictional approach will facilitate cooperation in dealing with the problems caused by ANS.

U.S. Coast Guard Programs

There are many regulations governing ballast water in the Great Lakes. The USCG established both regulations and guidelines for the control of ANS to comply with the NISA in 1996. The rule established voluntary ballast water management guidelines for all waters of the U.S. and established mandatory reporting and sampling procedures for all vessels to help limit the further introduction of ANS through ballast water.

NISA also directed the USCG to work in conjunction with the Smithsonian Environmental Research Center (SERC) to develop a National Ballast Water Information Clearinghouse to help gather information and data concerning ballast water management and ballast-mediated invasions. The Clearinghouse was established in 1997 at SERC. The U.S. Coast Guard and the Clearinghouse are implementing a nationwide program, the National Ballast Survey (NABS), to measure ballast water management and delivery patterns for commercial vessels arriving in U.S. ports to help create a national database on ballast water.

The U.S. Coast Guard also continues to work with the International Maritime Organization to develop international instruments for ballast water management.

Canadian Coast Guard Programs

The Canadian Coast Guard has had guidelines in place since 1989 regarding the voluntary open ocean exchange of ballast water for ships carrying fresh water ballast and wanting to travel into the St. Lawrence Seaway and the Great Lakes. The same ballast water exchange rules became mandatory in 1993 in the U.S. A salinity of greater than 30 parts per thousand is required for the ballast water of all ships entering the Great Lakes system. The Canadian Coast Guard works in conjunction with the Department of Fisheries and Oceans, the Marine Safety Branch of Transport Canada, and the USCG to ensure that ballast water guidelines are being met. It is important that application of any ballast water management regime be applied consistently to all vessels entering the system and that agencies not discriminate against vessels coming from certain trades or countries.

Currently, a major concern for the Canadian Coast Guard is the "no ballast on board" (NOBOB) issue (see the section on Prevention Activities for a discussion of NOBOB) and, as a result, research money has been dedicated to help find a resolution for this problem.

PEAC Petition

The Pacific Environmental Advocacy Center (PEAC) filed a petition with EPA requesting that EPA repeal its exemption of ballast water from National Pollutant Discharge Elimination System (NPDES) regulation under the Clean Water Act (CWA). Under current EPA regulations, vessels are exempt from having to acquire an NPDES permit in order to discharge ballast water. The petitioners contend that vessels are point sources of pollutants, as defined under the CWA, and should be required to obtain permits to discharge ballast water into U.S. waters. PEAC contends that ballast water not only contains the traditional pollutants of toxins and sediments, but also carries large numbers of non-indigenous species, which the PEAC argue qualify as biological pollutants as defined by the CWA. Therefore, in order to protect U.S. waters and native ecosystems from the threat posed by the various pollutants in ballast water as intended by the CWA, PEAC argues for the removal of the ballast water exemption. EPA is currently conducting a study to determine how it could most effectively bring its authority under the CWA or other statutes to bear on the problem of invasive species in ballast water. That study is scheduled for release in the spring of 2000.

Tribal Programs

The Great Lakes Indian Fish and Wildlife Commission (GLIFWC) has been working since 1986 in conjunction with the USFWS on the Sea Lamprey Control (SLC) Program. This program, along with programs of other agencies, works to gather information on adult sea lamprey to help find approaches to control and reduce the lamprey population. Lampreys ascend into various tributary streams of Lake Superior during their May-June spawning run.

The GLIFWC is also involved in strategies to control purple loosestrife in wetland ecosystems. They have seen success in loosestrife control through their use of chemical and biological (herbivorous beetles) controls in infested areas. For example, by their estimations, their strategies have reduced loosestrife cover in Fish Creek Sloughs on Chequamegon Bay, Lake Superior, by well over 90 percent and have started to control loosestrife along the Highway 13 corridor. GLIFWC has performed surveys to determine loosestrife distribution and has prepared GIS maps illustrating distribution and relative abundance of purple loosestrife in the surveyed areas. Further research on control activities is being performed by GLIFWC staff under a grant funded by the Natural Resources Conservation Service (NRCS). In addition to allowing for research on purple loosestrife control activities, the NCRS funds were used in the development of education materials to increase awareness and solicit help from the general public in controlling the spread of purple loosestrife.

In addition to participation in sea lamprey and loosestrife control programs, GLIFWC also works with efforts to control the spread of ruffe and zebra mussels in Lake Superior, participates in a variety of programs advocating native species, works with the Great Lakes Panel on various activities, takes part in the Stop the Invaders community outreach program, and co-occupies an ex-officio seat on the ANS Task Force.

Another tribal program, the Chippewa/Ottawa Treaty Fishery Management Authority (COTFMA) was created to manage and regulate the treaty fishery sections of the Great Lakes, including southeastern Lake Superior. The Inter-Tribal Fisheries and Assessment Program (ITFAP) is a division of COTFMA which is responsible for conducting research, assembling catch statistics, and recommending harvest quotas. The ITFAP has also worked on projects in conjunction with the USFWS Sea Lamprey Control Station and participated in the Sea Lamprey Control Program. In addition, the COTFMA is a signatory to the PEAC petition to amend the Clean Water Act exemption on ballast water discharge. On the national level, COTFMA co-occupies an ex-officio seat on the ANS Task Force.

Canadian Programs

Several Canadian agencies are involved in exotic species programs on the Great Lakes. Impacts of exotic species on the ecosystem are monitored by the OMNR's Lake Management Units and the federal Department of Fisheries and Oceans. The OMNR also participates in the ruffe surveillance program and the ruffe control program and is a member of the Great Lakes Panel on Aquatic Nuisance Species. In partnership with the Ontario Federation of Anglers and Hunters, Ontario operates an Invading Species Hotline for the reporting and maintenance of a central registry of new exotic species sightings and range extensions. This program also serves as the center for Ontario's exotic species public awareness program and acts as a single window information source for the public. A volunteer zebra mussel monitoring program is also coordinated through this program. The Canadian Coast Guard works in partnership with the U.S. Coast Guard on ballast water management issues.

The Great Lakes Ballast Water Technology Demonstration Project (GLBTDP)

The Great Lakes Ballast Water Technology Demonstration Project (GLBTDP) was initiated in 1996 by the Northeast-Midwest Institute and the Lake Carriers Association to help provide the shipping industry with a tool box of options. The goal of the program was to evaluate and help improve the operational and biological effectiveness of filtration as a primary treatment method for treating ballast water. Part of the testing took place aboard an operating commercial vessel, the *M/V Algonorth*, and part on a stationary barge in Duluth Harbor. This filtration testing was completed in 1998 with funding from the Great Lakes Protection Fund and the state of Minnesota through the Legislative Commission on Minnesota Resources. Filtration showed promise as a means of removing organisms above 50 microns. However, secondary treatment following filtration will be necessary to address unicellular phytoplankton organisms, bacteria and viruses. A secondary treatment demonstration jointly funded by the Great Lakes Protection Fund and the U.S. EPA's Great Lakes National Program Office is scheduled to be conducted in the summer of 2000.

10.5 EDUCATIONAL OUTREACH

Various educational and outreach measures have been implemented in the Lake Superior basin to help raise public awareness of the threat posed by ANS. The Minnesota Department of Natural Resources (MN DNR), Minnesota Sea Grant, Ontario Ministry of Natural Resources, Ontario Federation of Anglers and Hunters, Michigan Sea Grant, Wisconsin Department of Natural Resources, Wisconsin Sea Grant, USFWS, and others provide literature to the public to help them identify ANS, suggest ways to stop the spread of ANS, and provide information about laws pertaining to ANS. The MN DNR has also placed an emphasis on inspecting boats and informing boaters who leave infested waters to drain water and remove ANS.

The Minnesota Sea Grant Program is also active in educating the public about the impacts of ANS on the Minnesota ecosystem. The National Sea Grant Program offers an even wider array of literature describing the threat of ANS. This educational material includes I.D. cards for various species which include a detailed picture and description of the species, the areas the species are restricted to, what to do and whom to call if a specimen is found outside the listed area, and practices for reducing the transport of ANS between bodies of water. Other contributions from the Sea Grant Program include Traveling Trunks, distribution of MN DNR produced field guides on ANS, and training packages providing details of individual ANS. A Three State Exotic Species Boater Survey, conducted in part by funding from the National Sea Grant College, found that Minnesota put forth a high level of effort and used a variety of methods in getting out the message about ANS in an attempt to evaluate the effectiveness of change in boater behavior. Examples of such efforts in Minnesota include civil penalties for transporting ANS, road checks for the enforcement of regulations, and inspection/education programs at boat accesses to infested waters. Additionally, ANS messages have been presented on billboards, the cover of the fishing regulations pamphlet, via the media, at conferences/workshops and boat/sports shows, in fact sheets and brochures, and in educational packages distributed to lake and fishing associations.

Other programs in the Great Lakes area directed at educating the public about nonindigenous species include:

- National Aquatic Nuisance Species Clearinghouse
- The Sea Grant Nonindigenous Species Site (SGNIS)
- The National Zebra Mussel Training Initiative
- Great Lakes Sea Grant Network
- Exotic Aquatics and Zebra Mussel Mania Traveling Trunk Program
- Citizen Monitoring Program
- Purple Loosestrife Biocontrol Project
- Exotic Species Day Camp for Educators

10.6 DETECTION AND MONITORING EFFORTS

Detection and monitoring is also an important component of an ANS program. There are two goals in a successful monitoring and detection program. The first goal is to engage in early detection of new invaders poised to enter the Great Lake ecosystem since the best chance to control the spread of the species is at its first introduction. Second, continuous monitoring and surveillance of already existing ANS is needed to track their spread throughout the basin. Currently, the USFWS maintains a surveillance program for monitoring the spread of ruffe and round goby. GIS technology is used to track up to hundreds of ANS and their movement in the Great Lakes. An important part of this program is public education. All new reports of dozens of ANS are maintained in a national database by the U.S. Geological Survey's Florida Caribbean Science Center in Gainesville, Florida. The Michigan Department of Natural Resources monitors Lake Huron fish stocks through two Great Lakes Research Stations on Lake Huron. At these stations, measured changes in fish stocks due to harmful invaders and other external sources are monitored, especially the progress of sea lamprey control assessed using lake trout wounding rates and recovery of lake trout stocks.

There is currently a ruffe monitoring program in Lake Superior. The USFWS Lake Superior Biological Station has had ruffe populations and those of associated fish communities under surveillance since 1992. Under this program, likely locations of ruffe populations are surveyed and the range of ruffe is then monitored and the status of peripheral populations is investigated. The Lake Superior Biological Station is also monitoring ruffe populations in the St. Louis River.

Further monitoring efforts need to be created or expanded to help reduce the threat of future infestations by nonindigenous species.

10.7 PREVENTION ACTIVITIES

Once ANS has established a population, or naturalized, it is unlikely they can be eliminated. With a few exceptions (e.g., sea lamprey) non-native aquatic species **cannot** be controlled, except in confined areas, once they are established. By the time a non-native species is noticed it is usually well-established, and unless its distribution is constrained by very specific habitat requirements, it will become ubiquitous and uncontrollable. Hence, a major emphasis must be placed on prevention, and not solely on control, which is usually not a realistic option.

Ballast Water Management

The primary focus of prevention efforts has been ballast water management, including a national ballast management program under NISA of 1996. The issue of ballast water in preventing the introduction of nonindigenous species into the Great Lakes ecosystem is discussed in detail below.

All cargo ships contain huge ballast tanks. These tanks are filled in port to help steady ships as they travel, and are emptied once cargo is loaded. Each tank can hold millions of gallons of water, which can contain any and all of the aquatic life found in port waters and sediments; everything from bacteria and algae to worms and fish has been found in ballast water. All ships traveling into the Great Lakes are required to exchange ballast water in the open ocean prior to entry. However, despite the mandatory emptying of ballast tanks, organisms may establish permanent or semi-permanent communities in the layer of water and sediment that often remains at the bottom of the tanks. In these situations, adult organisms may reproduce and release larvae into ballast water, for eventual release in port, while adults remain in the sediment to reproduce further. In order to stop these harmful discharges, ships must takes steps to avoid taking organisms into ballast tanks, to kill organisms during the voyage, or to avoid discharging organisms when ballast water is released (MIT 1999). To test for compliance with ballast water exchange requirements, the Coast Guard has the authority to board all ships entering the Great Lakes and randomly sample ballast water for salinity, which is subsequently compared with the salinity standard. The Coast Guard recognizes that salinity cannot be the only method of verification of open ocean exchange at a coastal port.

Alternatives to ballast exchange as a means of control of organisms inhabiting ballast water include filtration, ultraviolet light, acoustics, salinity, heat, chemical biocides, sedimentation, pH treatment, oxygen deprivation, and discharge to reception vessels (Reeves 1996). Despite the available prevention technologies, it is unlikely that such solutions will be implemented by the shipping industry without incentives or regulations. The Canadian Coast Guard has expressed a need for biological standards for ballast tanks. Without such a restriction, the Canadian Coast Guard does not foresee voluntary implementation of new technologies for ballast water treatment. This is a forward looking initiative that will require participation of both the shipping industry and the ballast water management programs.

NISA Section 151.2035(b)(2) states that retaining ballast water on board is an option, and Section 151.2035(b)(4) states that discharging ballast water to an approved reception facility is another option. In order for the Coast Guard to approve a method alternative to ballast exchange, they must consider whether the method conforms to existing laws and standards, how effective the method is in reducing the viability of organisms within the vessel's ballast water, and how the vessel operator will verify that the system is operating as designed (U.S. Coast Guard 1999)

There are penalties for failing to comply with the Great Lakes ballast water provisions of NISA that include restriction of operation, revocation of Customs clearance, and possible civil and criminal penalties.

The NOBOB Issue

While adequate under many circumstances, ballast exchange poses safety, effectiveness, and accountability concerns that limit its scope and usefulness. The practice has particularly limited utility in the Great Lakes where most transoceanic vessels enter the system fully loaded with cargo and report NOBOB. They nonetheless transport organisms into the Great Lakes system in the residual water and sediment in the "empty" ballast tanks. A tool box full of alternative prevention technologies and practices is needed to address the range of vessel types and voyage patterns of today's waterborne transportation. In the long term, these tools may be solutions such as a combination of microfiltration and ultraviolet light treatments, which can be installed or designed into vessels. Technologies such as these could reliably resolve problems associated with fully-loaded vessels (NOBOB vessels) (Cangelosi 1997).

In an interim rule on implementation of the NISA Act of 1996 which became effective July 1, 1999, the Coast Guard presented its position on NOBOB vessels. “A vessel with NOBOB may not have a large quantity of ballast water on board, but the vessel does retain sediment and residual ballast water. The Coast Guard requests in this regulation that all vessels remove sediments in an appropriate manner on a regular basis. We are working on identifying possible management methods to reduce the threat of a vessel operator claiming NOBOB. However, it would be premature to issue regulations specifically for these vessels at this time. To ask a vessel operator in a NOBOB status to conduct a ballast water exchange could destabilize a vessel, causing it to submerge its load line or compromise seaworthiness by exceeding hull girder stress limits, or increase the stresses on the hull to the point they fracture.” (USCG 1999)

Other Prevention Programs

Another prevention program in the Great Lakes includes a proposal for setting up a quick response team that could be dispatched to an area where a newly introduced species has been reported to try to prevent the spread of the species beyond the introduction point. At this point in time, planning of such a team has not moved beyond the discussion stage but is still viewed as an option for future consideration.

Control Activities

Experts disagree about the relative importance of prevention and control. Effective control in aquatic systems is often impossible, but the impacts of ANS merit an attempt. Everyone agrees prevention is best, but it is difficult to measure success in prevention activities. Control activities need to be established and implemented to try to reduce the negative ecological and economic impact of nonindigenous species that have already been introduced into the Great Lakes ecosystem. At least partial success has been achieved in control programs with the sea lamprey, ruffe, and purple loosestrife.

ANS can be controlled by several general methods, including chemical, biological, mechanical or physical, and habitat management practices. While each of these methods may provide effective control, each has disadvantages as well. The use of chemicals raises concerns about environmental safety and long-term impacts. Identification and screening of biological control agents invariably takes many years, and improperly screened biological control agents have themselves become nuisance species in the past. Mechanical or physical controls are often very expensive. No single method is likely to provide the necessary control of nonindigenous species. Hence, a comprehensive control strategy involving a combination of techniques is often necessary for an effective control program.

Various control mechanisms are currently being implemented in the Great Lakes. To help control the expansion of the goby into other waterways, river barrier systems are being implemented, along with public education programs. Unfortunately, no effective measures have been found to date to decrease established populations of gobies. The ruffe is the subject of the first control program developed under the NANPCA. The control program was implemented in 1992 and has successfully delayed the spread of ruffe through the Great Lake and inland waters. This success was obtained largely through the campaign to limit the transport of ruffe, both intentionally and unintentionally, between bodies of water, particularly by controlling the transport of ruffe in ballast water carried out of Lake Superior. The control of ruffe has been given a great amount of attention because if they do spread, ruffe will pose a threat to fisheries and aquatic ecosystems throughout much of eastern North America.

The sea lamprey has cost millions of dollars in losses to fisheries and in costs of control, in addition to the depletion or extirpation of lake trout stocks. In 1956, a joint program between the United States and Canadian governments was implemented to address the harmful impacts of the sea lamprey. The Great Lakes Fishery Commission (GLFC) was created by the *Convention on Great Lakes Fisheries* between the United States and Canada in 1955, and control of sea lampreys within the Great Lakes basin was one of the Commission's principal responsibilities. The GLFC implemented sea lamprey control on the basis of an agreement between the U.S. and Canada reached at the Convention. The result was the development and application of an environmentally acceptable lampricide for use in controlling lamprey populations. Other mechanisms of control being used include mechanical and electrical barriers, and the experimental sterile-male-release-technique. These methods have achieved considerable success in controlling sea lamprey populations in the Great Lakes. Populations of sea lampreys in Lake Superior have been reduced to 10 percent of their former abundance, and the lake trout, their major prey, have recovered to self-sustaining populations in several areas. In other areas, lamprey predation continues to limit recovery of the lake trout.

While current activities have been moderately successful at preventing and controlling the effects of ANS, continued regulatory efforts and education programs are needed to help reduce the threat posed by these species in the Great Lakes.

10.8 RECOMMENDATIONS AND NEEDED ACTIONS

1. Engage in forecasting in an attempt to determine those species with exceptionally high invasion and impact potential, as suggested by Ricciardi and Rasmussen (1998) in a paper entitled, Predicting the identity and impact of future biological invaders: a priority for aquatic resource management, so that proper steps can be taken to halt the spread of such species before they become a threat.

2. Take additional steps to maximize the effective functioning of programs already in effect for the prevention and control of ANS. Suggested steps include:

   - Develop a detailed database of all ANS, including biological information, behavior, previous ecological impacts and any other information that might prove useful in understanding and stopping current and future invaders. This inventory could take the shape of an online information clearing house, including an online GIS with distribution data, data submission, and management activities.

   - Clarify the roles of the various responsible agencies with regard to the issue of ANS, including the role of the Great Lakes states in helping to prevent and control nuisance species. While a high level of national involvement is necessary, state action and participation will ensure that regional and local concerns are also being addressed.

   - Implement a system to ensure that duplication of effort is kept to a minimum, in order to optimize the use of the resources the agencies have available to them.

   - Encourage interjurisdictional cooperation and information sharing, not just clarification of roles and avoiding duplication. Foster partnerships with industry and stakeholder interests and raising and/or maintaining awareness at all levels.

   - Develop and incorporate short-term management practices applicable to fully-loaded vessels in Coast Guard ballast management regulations for the Great Lakes (Cangelosi 1997).

3. Management agencies are hampered by a lack of technology to control ANS once they have become established. Research and development leading to new analytical and management tools are desperately needed for an adequate response to ANS (Busiahn 1993). The following strategies could be pursued to counter the impacts of ANS:

   - Baseline data on fish communities could be collected to detect changes brought about by introduced species.

   - Surveillance sampling could be conducted in likely locations to detect new colonizations.

- Information and education programs could be developed and promoted, so that the public understands the threat of ANS, does not transport them, and reports suspected new occurrences.

- Transport and possession of ANS by the public or the live bait industry could be regulated or prohibited.

- Fishery management agencies could develop working relationships with the maritime and bait industries, the U.S. and Canadian Coast Guard, the U.S. Army Corps of Engineers, and other non-traditional partners in the effort to prevent the introduction and spread of ANS. The Great Lakes Panel on Aquatic Nuisance Species provides an established coordination mechanism.

- Fishery management agencies could promote greater resilience in aquatic communities by restoring and protecting habitat, and through careful deliberation of stocking and harvest regulation. Results of management actions could be measured by long-term monitoring programs.

4. Develop priorities for dealing with ballast water issues. Examples include:

   - Develop clear and concise standards for ballast tanks and discharge of ballast water.

   - Focus on "best practical technology" for ballast water control.

   - Devise a short-term plan for dealing with the NOBOB issue.

   - Require that newly built ships incorporate technology to deal with the ballast water problem.

   - Ensure that both the U.S. and Canada are working together on ballast water management, regulation, and enforcement to ensure effectiveness of any established programs.

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ADDENDUM 10-A
DOCUMENTED EXOTIC AQUATIC SPECIES IN LAKE SUPERIOR

Species Name	Year of Introduction	First Location	Intentional or Unintentional
Fish:			
Alewife (*Alosa pseudoharengus*)	<1953	NA	Unintentional
American eel (*Anguilla rostrata*)	1970	Brule River	Unintentional
Atlantic salmon (*Salmo salar*)	1972	WI waters	Intentional
Brown trout (*Salmo trutta*)	1883	MI waters	Intentional
Chinook salmon (*Onchorhynchus tshawytscha*)	1967	MI waters	Intentional
Coho salmon (*Oncorhynchus kisutch*)	1966	MI waters	Intentional
Common carp (*Cyprinus carpio*)	1891	WI waters	Unintentional
Eurasian ruffe (*Gymnocephalus cernuus*)	1986	St. Louis River	Unintentional
Fourspine stickleback (*Apeltes quadracus*)[a]	1986	Thunder Bay	Unintentional
Pink salmon (*Onchorhynchus gorbuscha*)	1956	Thunder Bay	Unintentional[b]
Rainbow smelt (*Osmerus mordax*)	1930	Whitefish Bay	Unintentional[b]
Rainbow trout (*Salmo gairdneri*)	1883	Lake Superior	Intentional
Round goby (*Neogobius melanostomus*)	1995	Duluth Harbor	Unintentional
Sea lamprey (*Petromyzon marinus*)	1938	Two Harbors	Unintentional
Threespine stickleback (*Gasterosteus aculeatus*) [a]	1994	Taconite Harbor	Unintentional
White perch (*Morone americana*)	1986	Duluth Harbor	Unintentional
Aquatic Invertebrates:			
Aquatic oligochaete (*Ripistes parasita*)	1987	S. Lake Superior	Unintentional
Asiatic clam (*Corbicula fluminea*)	1999	Duluth Harbor	Unintentional
Rusty crayfish (*Orconectes rusticus*) [a]	1999	St. Louis River	Unintentional
Spiny waterflea (*Bythotrephes cederstroemi*)	1987	E. Lake Superior	Unintentional
Zebra mussel (*Dreissena polymorpha*)	1989	Duluth Harbor	Unintentional
Diseases and Parasites:			
Furunculosis (*Aeromonas salmonicida*)	NA	NA	Unintentional
Microsporidian parasite (*Glugea hertwigi*)[c]	1930s	Wide distribution	Unintentional
Bacteria kidney disease (*Corynebacterium* ssp.) [a]	NA	NA	Unintentional
Whirling disease (*Myxobolus cerebralis*)	NA	NA	Unintentional
Wetland and Aquatic Plants:			
Bur reed (*Sparganium glomeratum*)	1936	Lake Superior	Unknown
Bittersweet nightshade (*Solanum dulcamara*)	<1843	Lake Superior	Intentional
Curlyleaf pondweed (*Potamogeton crispus*)	<1993	Lake Superior	Intentional
Eurasian watermilfoil (*Myriophyllum spicatum*) [a]	<1996	Bayfield	Unintentional
Purple loosestrife (*Lythrum salicaria*)	1907	Duluth	Intentional
Yard dock (*Rumex longifolius*)	1901	Isle Royal	Unintentional[d]

NA - Information not available

[a] Data yet to be confirmed

[b] Inadvertent introduction or spread resulting from intentional introduction elsewhere

[c] Spread with rainbow smelt introduction

[d] Inadvertent spread from cultivation

GLOSSARY

This glossary is a modified version of the Minnesota Sea Grant's "Glossary of the Great Lakes" (http//www.d.umn.edu/seagr/pubs/ggl.html).

2,3,7,8, tetrachlorodibenzo-p-dioxin TCDD
See Dioxin.

33 CFR 320-330
Federal regulations which identify Army Corps of Engineers (ACOE) general policies to implement Section 404 of the Clean Water Act. Part 320 outlines the ACOE's general policies; Part 321 -- permit regulations for dams and dikes; Part 322 -- permit regulations for structures; Part 323 -- permit regulations for dredged materials; Part 324 -- permit regulations for ocean dumping; Part 325 -- permit regulations for discharges to navigable waters and wetlands; Part 326 -- enforcement policies; Part 327 -- public hearings; Part 328 -- definition on navigable waters regulations; and Part 330 -- nationwide permit program regulations.

40 CFR
Federal regulations for air, waste, and water-related programs. Water-related regulations include the National Pollutant Discharge Elimination System (NPDES), water quality standards, discharges to navigable waters, other discharges, and test procedures. *See also* Code of Federal Regulations.

Abatement
A reduction in the degree or amount of pollution.

Accumulation
The build-up of a substance in a plant or animal due to repeated exposure to and uptake of that substance from the environment. *See also* bioaccumulation.

Acid Deposition
The total amount of pollutants that make up what is commonly referred to as acid rain. This includes both the wet deposition and dry deposition components that settle out of the atmosphere. *See* acid rain.

Acid Rain
Occurs when sulfur dioxide and nitrogen oxide emissions are transformed in the atmosphere and return to the earth in rain, fog, or snow. Acid rain can damage lakes, forests, and buildings, contribute to reduced visibility, and may harm human health. Regulations have been implemented at the federal and state (MN) level to reduce acid rain. Related programs: Clean Air Act, MN Rule Chapter 7009.

Acute Test
A comparative study in which organisms are subjected to different treatments and observed for a short period, usually not constituting a substantial portion of the organism's life span.

Acute Toxicity
Adverse effects to a plant or animal that result from an acute exposure to a stimulant, such as a

pollutant. The exposure usually does not constitute a substantial portion of the life span of the organism. In standard laboratory toxicity tests with aquatic organisms, an effect observed in 96 hours or less is typically considered acute. Also described as a stimulus severe enough to induce an effect.

Aerobic
A term that describes organisms or processes that require the presence of molecular oxygen.

Air Pollution Control Rules-Minnesota
MN state rules regulating air pollution and implementing requirements of the 1990 Clean Air Act Amendments (1990 CAAA). *See* Minnesota Rules Chapters 7007, 7009, and 7021. Related programs: Clean Air Act.

Air Toxics
Substances that cause or contribute to air pollution and which can cause serious health and environmental hazards, such as cancer or other illnesses. *See also* Hazardous Air Pollutants. Related programs: Clean Air Act, Minnesota Air Toxics Strategy.

Air Toxics Strategy
See Minnesota Air Toxics Strategy.

Algae
Simple plants found in water and elsewhere that have no roots, flowers, or seeds. These are usually microscopic plants and are the primary producers in lakes. *See also* phytoplankton and periphyton.

Ambient Toxicity
A measurement made using a standard toxicity test to determine how toxic a natural water body is. In some cases a water body may already possess some degree of toxicity before a known pollutant is discharged into it.

Anaerobic
A term that describes processes that occur in the absence of molecular oxygen. *See also* anoxia.

Anoxia
The absence of oxygen or a deficiency of oxygen that is harmful to living organisms. Anoxic conditions can develop in a lake bottom when oxygen is depleted by decomposition processes. This often happens in eutrophic lakes and can result in fish kills. *See also* anaerobic.

Anthropogenic
Anything that is human-caused or derived.

Anti-Backsliding
A federal policy to ensure that water bodies that have been improved are kept at that higher quality. Point source dischargers are required by governments to meet effluent limits, but if discharges become cleaner, or fall below the limit, they are not allowed to go up again. Relaxation of National Pollutant Discharge Elimination System permit limits are not allowed except in certain, limited circumstances.

Anti-Degradation
A federal policy to protect water quality. The policy states that the existing high quality of a particular water resource cannot get worse unless justified by economic and social development considerations. Contained in the U.S. Water Quality Guidance for the Great Lakes System. Related programs: Clean Water Act.

Aquatic Life Criteria
Water quality criteria designed to protect aquatic organisms, including fish, plants, and invertebrates. Related programs: Great Lakes Initiative, Clean Water Act.

Aquatic Nuisance Species (ANS)
Water-borne plants or animals that pose a threat to humans, agriculture, fisheries, and/or wildlife resources. *See also* non-indigenous species, zebra mussel, Bythotrephes, Eurasian ruffe, Eurasian watermilfoil.

Aquatic Nuisance Species Great Lakes Panel
A federal organization formed in 1991 by the Great Lakes Commission to advance exotic species research, monitoring, and control activities. The activities conducted are based on federal legislative and budgetary needs and research and management requirements. Activities include Great Lakes-wide education.

Aquatic Nuisance Species Task Force
An international organization that develops and implements programs to prevent the introduction and distribution of aquatic nuisance species. Their goal is to monitor, control, and study these species, and to disseminate technical and educational information. Made up of 19 provincial, state, and federal organizations.

Area of Concern (AOC)
Areas of the Great Lakes identified by the International Joint Commission as having serious water pollution problems requiring remedial action and the development of a Remedial Action Plan. AOCs are defined in the Great Lakes Water Quality Agreement as: "a geographic area that fails to meet the general or specific objectives of the Great Lakes Water Quality Agreement, or where such failure has caused or is likely to cause impairment of beneficial use or of the areas ability to support aquatic life." Initially, there were 43 AOCs in the Great Lakes Basin. The 8 AOCs in Lake Superior are: Deer and Torch Lakes in Michigan; St. Louis River in Minnesota and Wisconsin; Jackfish Bay, Nipigon Bay, Thunder Bay, and Peninsula Harbour in Ontario; and St. Mary's River in Michigan and Ontario. Related programs: Great Lakes Water Quality Agreement, Remedial Action Plans.

Army Corps of Engineers (ACOE)
The federal agency that administers the Section 404 permit program on dredging or filling navigable waters, including wetlands.

Arrowhead Regional Development Commission (ARDC)
One of several regional development commissions located throughout Minnesota, this one serves seven counties in northeastern Minnesota. Through its mission to provide local leadership it is involved in many issues related to the environment in the Lake Superior basin.

Atmospheric Deposition
Pollution that travels through the air and falls on land and water. Related programs: Clean Air Act, Great Lakes Toxic Reduction Effort.

Basin
The land area that drains into a lake or river. This area is defined and bounded by topographic high points around the water body. *See also* watershed.

Bayfield Institute
A Canadian federal organization that conducts fisheries research, habitat management, hydrographic surveys and chart production, fisheries and recreational harbor management, and ship support. Together with the work of the Freshwater Institute in Winnipeg, it provides the federal Fisheries and Oceans Program for Central and Arctic Canada.

Beneficial Use
The role that the government decides a water body will fulfill. Examples of these uses include healthy fish and wildlife populations, fish consumption, aesthetic value, safe drinking water sources, and healthy phytoplankton and zooplankton communities. Restoring beneficial uses is the primary goal of the Remedial Action Plans for the Areas of Concern and of the Great Lakes. Related programs: Great Lakes Water Quality Agreement, Lakewide Management Plans, Remedial Action Plans.

Beneficial Use Impairment
A negative change in the health of a water body making it unusable for a beneficial use that has been assigned to it. Examples of these use impairments, as designated in the Great Lakes Water Quality Agreement, include: restrictions on fish and wildlife consumption, beach closings, degradation to aesthetics, loss of fish and wildlife habitat, and restrictions on drinking water consumption. Related programs: Great Lakes Water Quality Agreement, Lakewide Management Plans, Remedial Action Plans.

Benthic
A term that describes both organisms and processes that occur in, on, or near a lake's bottom sediments. *See also* benthos.

Benthic Invertebrate
Refers to animals with no backbone or internal skeleton that live on the bottom of lakes, ponds, wetlands, rivers, and streams, and among aquatic plants. Benthic invertebrates provide an essential source of food for young and adult fish, wildlife, and other animals. Examples include caddisflies, midge larvae, scuds, waterfleas, crayfish, sponges, snails, worms, leeches, and nymphs of mayflies, dragonflies, and damselflies. The benthic invertebrate *Diaporeia*, is an ecosystem indicator.

Benthos
A term applied to organisms that live on or in a river or lake's bottom and/or bottom sediments. *See also* benthic.

Best Available Control Technology (BACT)
Technology required to reduce emissions of air pollutant. Defined in the Great Lakes Permitting

Agreement as: “emission limits, operating stipulations, and/or technology requirements based on the maximum degree of reduction which each Great Lakes State determines is achievable through application of processes or available methods, systems, and techniques for the control of listed pollutants, taking into account energy, environmental, and economic impacts, and other costs."

Best Available Technology (BAT)
The most effective, economically-achievable, and state-of-the-art technology currently in use for controlling pollution, as determined by the U.S. EPA.

Best Management Practice (BMP)
Methods used to control nonpoint source pollution by modifying existing management practices. BMPs include the best structural and non-structural controls and operation and maintenance procedures available. BMPs can be applied before, during, and after pollution-producing activities, to reduce or eliminate the introduction of pollutants into receiving waters. Related programs: Clean Water Act, Wetlands Conservation Act, Coastal Zone Management, Section 319.

Binational Policy Task Force
An international organization that provides overall policy coordination for the Binational Program. Representation includes federal, provincial, and state government agencies. Related Programs:Binational Program.

Binational Program
The commonly-used name for the Lake Superior Binational Program to Restore and Protect the Lake Superior basin. An international program developed by the governments of Canada, the U.S., Minnesota, Michigan, Wisconsin, and Ontario to protect the high quality waters of the Lake Superior basin and to restore those areas that have been degraded. These goals are to be met through pollution prevention, enhanced regulation, and special designations. One specific goal of the program is to achieve zero discharge and zero emission of designated persistent and bioaccumulative toxic substances from point sources in the basin. Related programs: Great Lakes Water Quality Agreement, International Joint Commission, the Broader Program.

Bioaccumulation
The net accumulation of a substance by an organism as a result of uptake from all environmental sources. As an organism ages it can accumulate more of these substances, either from its food or directly from the environment. Bioaccumulation of a toxic substance has the potential to cause harm to organisms, particularly to those at the top of the food chain. The pesticide DDT is an example of a chemical that bioaccumlates in fish and then in humans, birds, and other animals eating those fish. *See also* accumulation and biomagnification.

Bioaccumulation Factor (BAF)
The ratio of a substance’s concentration in an organism's tissue to its concentration in the water where the organism lives. BAFs measure a chemical’s potential to accumulate in tissue through exposure to both food and water. *See also* bioconcentration factor. Related programs: Great Lakes Initiative.

Bioaccumulative Chemicals of Concern (BCCs)
Any chemical which, upon entering surface waters, bioccumulates in aquatic organisms by a bioaccumulation factor greater than 1000. This formula takes into account metabolism and other factors that might affect bioaccumulation. Related programs: Great Lakes Initiative.

Bioassay
A test used to evaluate the relative potency of a chemical or mixture of chemicals by comparing its effect on a living organism with the effect of a standard preparation on the same organism. Bioassays are frequently used in the pharmaceutical industry to evaluate the potency of vitamins and drugs.

Bioavailability
A measure of how available a toxic pollutant is to the biological processes of an organism. The less the bioavailability of a toxic substance, the less its toxic effect on an organism.

Bioconcentration Factor (BCF)
The ratio of a substance's concentration in tissue versus its concentration in water in situations where the organism is exposed through water only. BCF measures a chemical's potential to accumulate in an organism's tissue through direct uptake from water (excludes uptake from food). *See also* bioaccumulation factor.

Biocriteria
See biological criteria.

Bioindicator
An organism and/or biological process whose change in numbers, structure, or function points to changes in the integrity or quality of the environment.

Biological Control
A method of controlling a disease-causing organism or pathogen or an exotic species. A biochemical product or bioengineered or naturally-occurring organism is used to cause death, inhibit growth, or inhibit the reproduction of an unwanted organism. One example is the import and use of the European beetle that feeds exclusively on Purple Loosestrife.

Biological Criteria
Biological measures of the health of an environment, such as the incidence of cancer in benthic fish species. Biological criteria can consist of narrative statements (in the simplest case) or of numeric statements.

Biological Oxygen Demand (BOD)
This is a measurement of the oxygen depletion in a water sample incubated under controlled conditions over a period of time. The aerobic decomposition of organic matter by bacteria in the sample requires oxygen. BOD is an important measurement of the impact that sewage discharge may have upon a water body because a certain amount of oxygen will be used in the breakdown of the wastewater.

Biomagnification
The process by which the concentration of a substance increases in different organisms at higher

levels in the food chain. For example, if an organism is eaten by another organism, these substances move up the food chain and become more concentrated at each step. *See also* bioaccumulation and accumulation.

Biomonitoring
The process of assessing the well-being of living organisms. Often used in water quality studies to indicate compliance with water quality standards or effluent limits and to document water quality trends.

Biosphere
A term that includes all of the ecosystems on the planet along with their interactions. The sphere of all air, water, and land in which all life is found. The Lake Superior Biosphere includes all ecosystems within the basin. Related programs: Lake Superior Biosphere Preserve.

Board of Water and Soil Resources (BWSR)
A Minnesota state agency that oversees a number of state programs designed to protect the state's soil and water. These programs include: the Soil and Water Conservation Districts, Comprehensive Local Water Management Plans, Conservation Reserve Program, Shoreland Block Grants, Reinvest in Minnesota, among others. BWSR is responsible for the Wetland Conservation Act and associated rules.

Boundary Waters
See Interstate Waters.

Boundary Waters Treaty
The international treaty between the United States and Great Britain signed on January 11, 1909, regarding the waters joining the two nations and relating to questions arising between the United States and Canada. It gave rise to the International Joint Commission. Related programs: Binational Program, International Joint Commission.

Broader Program
The portion of the Lake Superior Binational Program containing the Lakewide Management Plan and ecosystem approach pursuant to the Great Lakes Water Quality Agreement.

Bythotrephes BC
Also called the spiny water flea, this non-indigenous species has spread to all of the Great Lakes and some inland lakes. The impact that this new predator will have on the Great Lakes has yet to be determined, though it may compete for food with some fish.

Canada/Ontario Agreement (COA)
A federal/provincial agreement under which Canada's obligations to the Canada/U.S. Great Lakes Water Quality Agreement are coordinated and implemented. This 1994 agreement lists and defines 50 commitments specific to the restoration, protection, and conservation of the Great Lakes. Related programs: Great Lakes Water Quality Agreement.

Canadian Environmental Protection Act (CEPA)
A 1988 federal act designed to protect the people and environment of Canada from the effects of toxic substances.

Carcinogen
A substance that is known or suspected to cause cancer.

Center for Lake Superior Environmental Studies (CLSES)
The original name for the Lake Superior Research Institute. Related programs: University of Wisconsin-Superior.

Center for Water and the Environment (CWE)
One of three centers within the University of Minnesota's Natural Resources Research Institute. CWE provides basic environmental information essential to safe and sustainable natural resource development. Related programs: Natural Resources Research Institute.

Chlordane
A critical pollutant that was used as a pesticide until banned by the U.S. in 1983 (except for use in controlling underground termites). Chlordane bioaccumulates in the food chain. Concentrations are highest in fat and liver tissue of predatory species. It has been detected in lake trout and other wildlife. Related programs: Binational Program.

Chlorinated Organic Compounds
Organic chemicals that contain PCBs, DDT, chlorinated dioxins and furans, dieldrin, and hexachlorobenzene. Also called organochlorines or chlorinated organics.

Chlorination
The addition of chlorine to water for disinfection. Used in drinking water purification and sewage treatment prior to discharge.

Chlorine
A common, naturally-occurring element. One form of chlorine is a highly poisonous gas that is typically used for water disinfection, sewage treatment, and the manufacture of bleach and other chemicals.

Chronic Test
A comparative study in which organisms are subjected to different treatments and observed for a long period or a substantial portion of their life span.

Chronic Toxicity
A harmful and delayed response (such as death, unusual growth, reduced reproduction, or disorientation) to a chemical that causes adverse effects over a long period of time relative to an organism's natural life span. In standard laboratory tests an effect observed in 96 hours or more is considered a chronic effect. *See also* toxicity test.

Clean Air Act (CAA)
Federal law originally passed in 1970 for the purpose of protecting and enhancing the quality of the nation's air resources. *See also* Clean Air Act Amendments of 1990.

Clean Air Act Amendments of 1990 (CAAA)
Federal legislation passed in 1990 that amended the Clean Air Act. It resulted in major changes further limiting the generation of air pollution in the United States. Significant sections of the 1990 CAAA include:

- Title I - National Ambient Air Quality Standards;
- Title II - Mobile Sources (e.g. automobiles);
- Title III - Air Toxics;
- Title IV - Acid Rain;
- Title V - Permit Program; and
- Title VI - Ozone-depleting Chemicals.

Related programs: Clean Air Act.

Clean Water Act (CWA)
A federal law that identifies national requirements to protect the nation's waters. Originally known as the Federal Water Pollution Control Act. The CWA is divided into six subchapters:

- Subchapter I - Research and Related Programs;
- Subchapter II - Grants for Construction of Treatment Works;
- Subchapter III - Standards and Enforcement;
- Subchapter IV - Permits and Licenses;
- Subchapter V - General Provisions; and
- Subchapter VI - State Water Pollution Control Revolving Fund.

The law provides for pretreatment standards, plans involving point and nonpoint source pollution, and effluent limitations that satisfy the act's intent.

Clean Water Act Reauthorization (CWAR)
The name for a federal legislative process to amend the Clean Water Act. It is anticipated that the CWA will be reauthorized in the mid- to late-1990s.

Coastal
Waters in the Great Lakes basin, coastal waters are defined in the Coastal Zone Management Act as the waters within the territorial jurisdiction of the United States, consisting of the Great Lakes, their connecting waters, harbors, roadsteads, and estuary-type areas such as bays, shallows, and marshes. Related programs: Coastal Zone Management Act.

Coastal Zone Act Reauthorization Amendments of 1990 (CZARA)
Federal legislation reauthorized by Congress in 1990, resulting in states being asked to combat the problems of coastal water quality, specifically nonpoint source pollution. CZARA also encourages states to tackle issues such as wetland loss, cumulative and secondary impacts of growth, increased threats to life and property from coastal hazards, and dwindling opportunities for public access to the shoreline. Related programs: National Oceanic and Atmospheric Administration, U.S. EPA.

Coastal Zone Management Act (CZMA)
A federal law enacted in 1972 to deal with increasing stresses on the nation's coastal areas, including the Great Lakes. Administered by National Oceanic and Atmospheric Administration (NOAA), the CZMA provides money, technical help, and policy guidance to states for balancing conservation and development of coastal resources. Under CZMA, states voluntarily develop their own Coastal Zone Management programs. Related programs: National Oceanic and Atmospheric Administration.

Code of Federal Regulations (CFR)
Federal regulations on how to implement federal law.

Combined Sewer Overflow (CSO)
Occurs when heavy rainfall or thaw conditions overload a sewer system designed to carry both waste and stormwater. Often the result is the discharge of untreated sewage into receiving waters. Also refers to the outfall structures themselves.

Comparative Risk Analysis
A procedure for ranking environmental problems by their seriousness (relative risk) for the purpose of assigning program priorities. Typically, teams of experts put together a list of problems, sort the problems by types of risk, then rank them by measuring them against standards, such as the severity of effects, the likelihood of the problem occurring among those exposed, the number of people exposed, and the like. Relative risk is then used to set priorities. *See also* risk assessment, risk management, ecological risk assessment.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or Superfund
A federal law, better known as Superfund, enacted in 1980 to give the EPA authority and money to take corrective measures and clean up hazardous waste sites. The 1986 Superfund Amendment Reauthorization Act (SARA) outlined preferred cleanup methods, including permanent on-site treatment.

Comprehensive Local Water Management Plan
See County Water Plan.

Confined Disposal Facility (CDF)
A facility providing a contained disposal area for contaminated sediments removed during dredging operations. Related programs: County Water Plan.

Cost-Benefit Analysis
The determination of how much it will cost to achieve a benefit, for example from pollution control, and the comparison of this amount to the cost of obtaining a higher or lower level of the benefit, or the cost of using some other alternative method.

Council of Great Lakes Governors (CGLG)
An organization comprised of the governors of the eight Great Lakes States who declared their shared intention to manage and protect the water resources of the Great Lakes basin through the Great Lakes Charter and the Great Lakes Toxic Substances Control Agreement.

Council of Great Lakes Industries (CGLI)
An organization that represents businesses with significant investments, facilities, products, and/or services in the Great Lakes basin, including manufacturing, utilities, telecommunications, transportation, financial, and trade. CGLI provides a focal point for offering industry's views and resources. It strengthens regional efforts to integrate social, economic, and environmental issues as a way to build a more vital Great Lakes basin.

Council of Great Lakes Research Managers
A binational advisory group to the International Joint Commission to evaluate the status of Great Lakes research.

County Water Plan
Also called Comprehensive Water Management Plans. These plans are developed by Minnesota counties to identify water resource problems and provide sound planning to prevent future problems. A bill was passed by the Minnesota State Legislature in 1985 encouraging counties to develop and implement County Water Plans. Related programs: Board of Water and Soil Resources, Clean Water Act.

Criteria
See water quality criteria.

Criteria Pollutants
A group of air and water pollutants regulated by the EPA under the Clean Air Act and Clean Water Act on the basis of criteria that includes information on health and environmental effects. Criteria pollutants include particulates, some metals, organic compounds, and other substances attributable to discharges.

Critical Pollutant
Chemicals that persist at levels that are causing or could cause impairment of beneficial uses lakewide. Other critical pollutants will be added to the list, but the Lake Superior Lakewide Management Program will first focus on the same nine critical pollutants identified in the zero discharge demonstration program (TCDD, OCS, HCB, chlordane, DDT, dieldrin, toxaphene, PCBs, and mercury). *See also* Great Lakes Critical Pollutants. Related programs: Lakewide Management Program, Binational Program, Zero Discharge Demonstration Program.

Decomposition
The breakdown of complex organic substances into more simple organic chemicals or substances. The ultimate product of decomposition in an aerobic environment is carbon dioxide.

Designated Scientific and Natural Areas (SNA)
See Scientific and Natural Areas.

Designated Uses
The role that a water body is slated to fulfill, such as a drinking water source. Uses are specified in water quality standards for each water body or segment, whether or not the current water quality is high enough to allow the designated use. Other typical uses of a water body include propagation of fish and wildlife, recreation, agriculture, industry, and navigation.

Dichlorodiphenyltrichloro-ethane, DDT
DDT, one of the nine critical pollutants, was commonly used as an insecticide after World War II and is now banned in the U.S. and Canada. DDT and its metabolites are toxic pollutants with long-term persistence in soil and water. They concentrate in the fat of wildlife and humans and may disrupt the human body's chemical system of hormones and enzymes. DDT caused eggshell thinning in a number of fish-eating birds and is associated with the mortality of embryos and sterility in wildlife, especially birds. DDT still enters the Great Lakes, probably from a number

of sources including airborne transport from other countries, leakage from dumps, and the illegal use of old stocks. Related program: Binational Program.

Dieldrin
Dieldrin, a critical pollutant, was used as a pesticide for veterinary uses and to control soil insects. In the U.S. and Canada, its use is now restricted to termite control. Dieldrin has a long half-life in shallow waters compared to most chlorinated organic compounds. It is acutely toxic and poses a potential carcinogenic threat to humans. This chemical enters the Great Lakes System from the air or contaminated sediments and has been detected in fish and wildlife in all of the Great Lakes. Related program: Binational Program.

Dioxin
A critical pollutant considered to be highly toxic, 2,3,7,8 tetrachlorodibenzo-p-dioxin, or TCDD, is a variant in a family of 75 chlorinated organic compounds referred to as dioxins. An unwanted chemical byproduct of incineration and some industrial processes that use chlorine, dioxin tends to accumulate in the fatty tissue of fish. Dioxin is a suspected human carcinogen. Related program: Binational Program.

Discharge
Any release or unloading of a substance or materials from a pipe, or other emission source. The addition of any pollutant to the waters of the state or to any disposal system from a point source. Related programs: 40 CFR.

Discharge of Dredged or Fill Material
Any addition of dredged or fill material into navigable waters or into the waters of the United States. This includes the driving of pilings and the addition of any material that changes the bottom elevation or configuration of a water body or material that might destroy or degrade any navigable water. Related programs: Section 404, 33 CFR.

Dry Deposition
The deposition of pollutants from the atmosphere (such as dust and particulate matter) that occurs during dry weather periods. Dry deposition rates are often drastically different than wet deposition rates.

Duluth-Superior Port Plan
A local program where the MN DNR is required to establish a port plan before it can authorize the filling of protected waters for port development. The plan includes provisions to protect designated natural resources areas, and to adopt a policy of no net loss for wetlands, fish habitat, and aquatic communities in the St. Louis River and Estuary.

Ecological Risk Assessment
An organized procedure to evaluate the likelihood that adverse ecological effects will occur as a result of exposure to stressors related to human activities, such as the draining of wetlands or release of chemicals.

Ecosystem
A biological community and its environment working together as a functional system, including transferring and circulating energy and matter.

Ecosystem Charter for the Great Lakes Basin
Initiated by the Great Lakes Commission, this is a binational statement of goals, objectives, principles, and action items for the Great Lakes with a plan for achieving it. This non-binding agreement supports a philosophy of "ecosystem management that recognizes natural resources as part of a dynamic and complete matrix that pays no heed to political boundaries or jurisdictions. Related programs: Great Lakes Commission.

Ecosystem Indicator
An organism or community of organisms that is used to assess the health of an ecosystem as a whole. For example, the Binational Program has selected the lake trout and *Diaporeia* (a benthic invertebrate) to be indicator species for Lake Superior. Related programs: Binational Program.

Ecosystem Principles and Objectives for Lake Superior
A binational program described in Volume IV of the Lake Superior Lakewide Management Program. The report lists specific ecosystem principles and objectives for the Lake Superior basin, provides a set of benchmarks, and helps guide decisions pertaining to land and water management in the Lake Superior ecosystem. Related programs: Binational Program.

Effluent
Liquid wastes that are discharged into the environment as a by-product of human-oriented processes, such as waste material, liquid industrial refuse, or sewage.

Effluent Limitation
Any restriction placed on quantities, discharge rates, and concentrations of pollutants that are discharged from point sources into waters of the United States or the ocean. Related programs: 40 CFR, Clean Water Act.

Endangered Species Act (ESA)
Federal statutes passed in 1973 that protect endangered and threatened species. The act has 16 sections.

Endangered Species Act Reauthorization (ESAR)
The name for the federal legislative process to amend the Endangered Species Act. It is anticipated that reauthorization will occur in the mid- to late-1990s.

Environment Canada (EC)
The lead federal agency responsible for implementing Great Lakes 2000 and the 1994 Canada-Ontario Agreement respecting the Great Lakes Basin ecosystem. Together, Great Lakes 2000 and the Canada-Ontario Agreement represent the Canadian response to the Great Lakes Water Quality Agreement.

Environmental Impact Assessment (EIA)
A decision-making process mandated under the National Environmental Policy Act (NEPA) which may require a detailed environmental impact statement analyzing the potential significant environmental impacts and alternatives to the action before the action is permitted. A public comment period takes place on each EIA.

Environmental Impact Statement (EIS)
A statement detailing the environmental impacts of and the alternatives to an action. *See* Environmental Impact Assessment.

Environmental Monitoring and Assessment Program (EMAP)
A federal program initiated by the EPA in 1988 to provide improved information on the current status and long-term trends in the condition of the nation's ecological resources. Seven resource categories are defined: near coastal waters, the Great Lakes, inland surface waters, wetlands, forests, arid lands, and agroecosystems. Related programs: Environmental Protection Agency.

Environmental Protection Agency (EPA)
A federal agency whose primary goal is to prevent or mitigate the adverse impacts of pollution on human health and the environment.

Environmental Research Laboratory (ERL) Duluth
See Mid-Continent Ecology Division.

Erosion
The wearing away of the land surface by running waters, glaciers, winds, and waves. Erosion occurs naturally from weather or runoff but can be intensified by land-clearing practices related to farming, residential or industrial development, road building, or timber cutting.

Estuary (Freshwater)
Areas of interaction between rivers and nearshore lake waters, where seiche activity and river flow create a mixing of lake and river water. These areas may include bays, mouths of rivers, marshes, and lagoons. These ecosystems shelter and feed fish, birds, and wildlife. Most importantly, Great Lakes estuaries provide habitat for wildlife and for young-of-the-year and juvenile fish.

Eurasian Ruffe
A non-indigenous species now found in Lake Superior and Lake Huron. This relatively new invader is a member of the perch family. It is usually less than 6 inches long, has a perch-like body shape, and is very slimy when handled. This fish may be competing with native perch and other fish for food. There is a great deal of concern over the potential for this fish to expand its range into other North American waters. It has also been called the European ruffe and river ruffe. *See also* aquatic nuisance species.

Eurasian Watermilfoil
An exotic aquatic macrophyte that forms thick underwater stands of tangled stems and vast mats of vegetation on the surface of inland lakes. In many shallow areas this plant can crowd out native plants and interfere with water recreation such as boating, fishing, and swimming. The plant can spread from lake to lake by stem fragments that cling to boats and trailers. Public education campaigns aimed at preventing unintentional transport of the plant by boaters have successfully slowed its spread in some states. *See also* aquatic nuisance species.

Eutrophic
A term used to classify those lakes of high primary productivity as indicated by high algal concentrations or high nutrient levels. *See also* eutrophication.

Eutrophication
The process of physical, biological, and chemical changes that occurs in a lake when enriched by nutrients, organic matter, and/or silt and sediments. The process can occur naturally, but if accelerated by human activities such as agriculture, urbanization, and industrial discharge, it is called cultural eutrophication.

Exotic Species
See non-indigenous species.

Exposure
Contact with a chemical or physical agent.

Exposure Assessment
Estimates the amount of a substance something is exposed to.

Fecal Coliform
Bacteria that come from the intestines of humans and other large animals. A high coliform count in a water body indicates human or animal sewage is leaking or being dumped into the lake.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)
Originally adopted in 1947 and currently enforced by EPA, this law regulates the marketing of pesticides.

Federal Register
The official document of the U.S. government that announces proposed federal rules and regulations. It signals the beginning of a period of time for public review and comment.

Federal Water Pollution Control Act (FWPCA)
A federal law that identifies national requirements to protect the nation's waters. Commonly referred to as the Clean Water Act (CWA). Related programs: Clean Water Act.

Fill Material
Material used to convert a water body into dry land or change its configuration or bottom elevation. Related programs: Section 404, 33 CFR, Wetlands Conservation Act, Wetlands Conservation Act Rules.

Fish Consumption Advisory (FCA)
An advisory issued by a government agency recommending that the public limit their consumption of fish. Advisories are issued to limit exposure to toxic substances in the fish that have the potential to impact human health. A fish consumption advisory is prepared annually by the Minnesota Department of Health. Fish caught from selected lakes and streams are tested for toxic substances (mercury, sometimes PCBs and dioxins). Many of the lakes tested have restrictions on fish consumption due to high mercury levels. PCBs and dioxin levels in fish have also resulted in suggested restrictions on fish consumption in some lakes and streams. Other states and the federal government also issue advisories.

Five-Year Strategy
See Great Lakes Five-Year Strategy.

Flushing Time
See residence time.

General Permit
An Army Corps of Engineers (ACOE) authorization that is issued on a nationwide or regional basis for categories of human activities within navigable waters of the U.S. General permits are issued when: (1) these activities are substantially similar in nature and cause only minimal individual and cumulative environmental impacts; or (2) the general permit would result in avoiding unnecessary duplication of the regulatory control exercised by another federal, state, or local agency provided it has been determined that the environmental consequences of the action are individually and cumulatively minimal. There are three types of general permits: regional permits, nationwide permits, and programmative permits. Related programs: Section 404, 33 CFR.

Glossary of the Great Lakes (GGL)
You are reading it!

Great Lakes
Lake Ontario, Lake Erie, Lake Huron (including Lake St. Clair), Lake Michigan, and Lake Superior, and the connecting channels (St. Mary's River, St. Clair River, Detroit River, Niagara River, and St. Lawrence River to the Canadian border).

Great Lakes 2000 (GL2000)
Led and implemented by Environment Canada, GL2000 is based on a vision of sustainable development in the Great Lakes Basin, with specific objectives of restoring degraded ecosystems, preventing and controlling pollutant impacts, and conserving human and ecosystem health. Other participating federal agencies include the Department of Fisheries and Oceans, Health Canada, Agriculture and Agri-food Canada, Transport Canada, Canadian Heritage, and Public Works and Government Service Canada.

Great Lakes Atmospheric Deposition Network
See Integrated Great Lakes Atmospheric Deposition Network.

Great Lakes Basin
See Great Lakes System.

Great Lakes Charter
An international organization formed in 1985 by the premiers of Ontario and Quebec and the governors of the 8 Great Lakes States in response to the increased interest in diverting Great Lakes water to arid regions of the U.S. The Charter does not encourage these diversion proposals, but has no enforcement powers to prevent their implementation.

Great Lakes Commission (GLC)
A Great Lakes states' organization formed in 1955 by the states of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin to promote a cleaner environment, stronger economy, and better quality of life for residents of the Great Lakes states. Although Canada is not an official member of the Commission, it is on the task force. Through policy development, intergovernmental coordination, and advocacy, the Commission offers a variety of

services to member states, and provides a unified and influential regional voice on policy, program, and legislative matters affecting the Great Lakes. It maintains an active observer program with representation from federal agencies, provincial governments, regional organizations, and tribal authorities. The Commission also maintains the Great Lakes Information Network and initiated the Ecosystem Charter for the Great Lakes Basin.

Great Lakes Critical Pollutants (GLCP)
Substances (a total of 138) currently identified as most critical to improving water quality under four major Great Lakes initiatives: the Great Lakes Water Quality Initiative, the Lake Michigan Lakewide Management Plan, the Lake Ontario/Niagara River Four Party Agreement, and the Lake Superior Binational Program Agreement. Each of the four initiatives may define critical pollutants differently.

Great Lakes Critical Programs Act
Amendments to Section 118 of the federal Clean Water Act in 1990 to improve the effectiveness of EPA's existing programs in the Great Lakes. The Critical Programs Act established the Great Lakes Water Quality Initiative and identified key treaty agreements between the United States and Canada in the Great Lakes Water Quality Agreement. The Act required the EPA to establish statutory deadlines for treaty activities and increased federal resources for the program. It also requires the EPA to publish proposed water quality guidelines for the Great Lakes System. The guidelines must specify minimum requirements for waters in the Great Lakes system in three areas: water quality standards; anti-degradation policies; and implementation procedures. Related programs: Clean Water Act, Great Lakes Initiative.

Great Lakes Enforcement Strategy
A federal program that is a joint effort of the eight Great Lakes States and the EPA. The strategy is a part of the process for implementing the Great Lakes Five-Year Strategy for the National Pollutant Discharge Elimination System program by reducing dischargers' non-compliance in the Great Lakes basin and reducing toxics loading. A key element of the strategy is the use of screening criteria that are more stringent than the national definition of significant non-compliance.

Great Lakes Environmental Research Laboratory (GLERL)
A federal research facility run by the National Oceanic and Atmospheric Administration located in Ann Arbor, Michigan. The GLERL's mission is to conduct integrated, interdisciplinary environmental research in support of resource management and environmental services in coastal and estuarine water, with special emphasis on the Great Lakes. GLERL's research provides federal, state, and international decision and policy makers with scientific understanding of:

1. sources, pathways, and fates of toxicants;
2. natural hazards;
3. ecosystems and their interactions;
4. hydrology and Great Lakes water levels; and
5. regional effects related to global climate change.

Related programs: National Oceanic and Atmospheric Administration.

Great Lakes Fishery Commission (GLFC)
An international organization established in 1955 by Canada and the United States. Located in

Ann Arbor, Michigan, the GLFC works to improve the Great Lakes fishery, coordinates efforts of the two nations, and implements management of the sea lamprey. The Commission also advises the two governments on other non-indigenous species. The USFWS is the U.S. agency that acts for the Commission. Related programs: United States Fish and Wildlife Service (Dept. of Fisheries and Oceans), Sea Lamprey Control Program.

Great Lakes Five-Year Strategy (1992)
A federal (EPA) program that commits the states, tribes, and U.S. federal agencies responsible for environmental protection and natural resource management in the Great Lakes basin to achieving specific environmental goals. This overarching EPA strategy provides a framework for EPA's Great Lakes Programs and contains three major areas of focus: reduction of toxic pollutants; restoration of habitat; and protection of the health of all species. Specifically, regarding toxics reduction (as set forth in the Great Lakes Water Quality Agreement with Canada), the Strategy calls for "...reducing the level of toxic substances in the Great Lakes System with an emphasis on persistent toxic substances, so that all organisms are adequately protected and toxic substances are virtually eliminated from the Great Lakes ecosystem." Related program: National Pollutant Discharge Elimination System.

Great Lakes Indian Fish and Wildlife Commission (GLIFWC)
An organization of Native American tribes from Michigan, Wisconsin, and Minnesota that assists member tribes in the management of natural resources, in the protection of ecosystems, and in the development of institutions of tribal self-government.

Great Lakes Information Network (GLIN)
A nationwide Internet information exchange service for the Great Lakes basin. GLIN ties together a host of databases and file servers from a wide range of government and academic groups in an easy-to-access format. Maintained by the Great Lakes Commission. Related Program: Great Lakes Commission.

Great Lakes Initiative (GLI)
GLI is the commonly used name for the Water Quality Guidance for the Great Lakes System. This federal guidance, drafted in 1993 and finalized on March 23, 1995, has regulatory implications, establishing minimum water quality standards, anti-degradation policies, and implementation procedures for waters in the Great Lakes system. Related programs: Great Lakes Toxic Reduction Initiative, Great Lakes Toxic Reduction Effort, Clean Water Act.

Great Lakes Laboratory for Fisheries and Aquatic Sciences (GLLFAS)
As a component of the Bayfield Institute, this Canadian laboratory conducts research on the persistence and impacts of toxic chemicals on Great Lakes fish communities and food chains, and studies fish habitat for factors that affect production, species associations, and rehabilitation potential of fish stocks. It is also responsible for implementing the federal Fish Health Regulations for Ontario. Research helps support the 1987 Great Lakes Water Quality Agreement and binational concerns related to the long-range transport of atmospheric pollutants.

Great Lakes Maritime Industry Voluntary Ballast Water Management Plan for the Control of Ruffe in Lake Superior
Co-sponsored by the maritime shipping industry Great Lakes-wide, the plan is designed to reduce

the risk that commercial vessels will transport the Eurasian ruffe in ballast water from Duluth-Superior Harbor to other ports. It requires that ballast water be exchanged in deep, cold water areas of Lake Superior. Commonly referred to as the Voluntary Ballast Water Management Plan.

Great Lakes National Program Office (GLNPO)
A federal EPA office created in 1978 to oversee the U.S. fulfillment of its obligations under the Great Lakes Water Quality Agreement with Canada. It was mandated by the Clean Water Act in 1987 to be responsible for coordinating the U.S. response to the water quality agreement. Located in Chicago, Illinois, GLNPO is made up of scientists, engineers, and other professionals who work with staff throughout the EPA, Great Lakes states, other federal agencies, Environment Canada, Ontario provincial government, International Joint Commission, colleges, universities, and the public. GLNPO developed the Great Lakes Five-Year Strategy to focus the activities of these groups on the following objectives: reduction of toxic substance levels, protection and restoration of habitats, and the protection of health. Related programs: Great Lakes Water Quality Agreement, Environmental Protection Agency, Great Lakes Five-Year Strategy, International Joint Commission.

Great Lakes Natural Resource Center
This is a private wildlife protection group located in Ann Arbor, Michigan and run by the National Wildlife Federation. Their Lake Superior Project focuses on the environmental problems of Lake Superior.

Great Lakes Protection Fund (GLPF)
A program initiated by the governors of the Great Lakes states as the United States first multi-state environmental endowment, the Fund is guided by principles stressing regional cooperation and communication with the purpose of promoting a healthy and sustainable Great Lakes ecosystem.

Great Lakes Regional Office
See Great Lakes Water Quality Advisory Board.

Great Lakes Research Office
This federal office, administered by the National Oceanic and Atmospheric Administration, identifies issues relating to Great Lakes resources on which research is needed, inventories existing research programs, establishes a mechanism for information exchange, and conducts research through the Great Lakes Environmental Research Laboratories, the National Sea Grant College Program, and other federal labs and the private sector. Related programs: Clean Water Act, National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratories, National Sea Grant College Program.

Great Lakes Science Advisory Board (SAB)
See Science Advisory Board.

Great Lakes Sea Grant Network
A U.S. network consisting of Sea Grant programs in Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, and New York.

Great Lakes Sport Fishing Council
A binational organization of the Great Lakes sportfishing community concerned with the present and future health of sportfishing, natural resources, and the Great Lakes ecosystem in general.

Great Lakes States
The states of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin.

Great Lakes States Air Permitting Agreement
A federal program signed by the environmental administrators of the Great Lakes states in 1988 to assure consistent implementation of the Toxic Substances Management in the Great Lakes basin through the permitting process agreement.

Great Lakes System
All the streams, rivers, lakes, and other bodies of water within the drainage basin of the Great Lakes.

Great Lakes Toxic Substances Control Agreement
An interstate agreement signed by the governors of the eight Great Lakes states in 1986, this agreement seeks uniform water quality standards for the Great Lakes. The purpose of the governors' agreement was to establish a framework for coordinated regional action in controlling toxic substances entering the Great Lakes system.

Great Lakes Toxics Reduction Effort (GLTxRE)
This is a federal/state partnership that seeks to reduce the generation and release of toxics to the Great Lakes basin, with an emphasis on nonpoint sources. It supports the Great Lakes Water Quality Agreement and Great Lakes Five-Year Strategy. EPA and the Great Lakes states have established a process to deal with gaps or barriers to effectively preventing, controlling, or eliminating toxics loadings from nonpoint sources. An EPA team works with federal and state Great Lakes agencies to enhance efforts to reduce Great Lakes critical pollutants through three parallel projects: Virtual Elimination, Lake Michigan Mass Balance, and source pathway analysis. Related program: Great Lakes Initiative.

Great Lakes Toxics Reduction Initiative (LtxRI)
The original name for the Great Lakes Toxics Reduction Effort.

Great Lakes Water Quality Advisory Board
A binational advisory group to the International Joint Commission to assist in evaluating progress by Canada and the U.S. in accomplishing the Great Lakes Water Quality Agreement goals and to make recommendations regarding the development and implementation of programs. Related programs: Great Lakes Water Quality Agreement, International Joint Commission.

Great Lakes Water Quality Agreement (GLWQA)
An international agreement signed by the United States and Canada in 1972 and updated in 1978 and in 1987. The Agreement seeks to restore and maintain full beneficial uses of the Great Lakes system. Language committing the two nations to virtually eliminate the input of persistent toxic substances in order to protect human health and living aquatic resources was included when the

agreement was updated in 1978. The philosophy adopted by the two governments is zero discharge of such substances. Related programs: Lakewide Management Program, Remedial Action Plans.

Great Lakes Water Quality Guidance (GLWQG)
See Water Quality Guidance for the Great Lakes System and the Great Lakes Initiative. Related programs: Great Lakes Toxic Reduction Initiative, Clean Water Act.

Great Lakes Water Quality Initiative (GLWQI)
A federal program initiated in 1989 by the EPA and the Great Lakes states to further address the environmental concerns identified in the Great Lakes Toxic Substances Control Agreement. The GLWQI was intended to provide a forum for the Great Lakes states and the EPA to develop uniform water quality criteria and implementation procedures for the Great Lakes basin so as to create an even playing field for all industries in the region. This was proposed in 1993 as the Water Quality Guidance for the Great Lakes System. Related programs: Great Lakes Toxic Reduction Initiative, Great Lakes Initiative.

Great Waters Program
This program was mandated by Title III of the 1990 Clean Air Act Amendments to assess the extent of atmospheric deposition of hazardous air pollutants to the Great Lakes and other designated waters. It includes setting up the Great Lakes Atmospheric Deposition Network and reporting the monitoring results from the network to investigate sources and deposition rates of air toxics, to find out what proportion of pollutants come from the atmosphere, and to evaluate any harmful effects to public health or the environment. Related program: 1990 Clean Air Act Amendments.

Great Waters Study
See Great Waters Program.

Ground Water
Water that occurs beneath the ground surface in soils and geologic formations.

Half-Life
The period of time necessary for one half of a substance introduced to a living system or ecosystem to be eliminated or disintegrated by natural processes.

Hazardous Air Pollutants (HAPs)
Any air pollutant listed as such in Title III of the 1990 Clean Air Act Amendments. These are chemicals that have the potential to cause serious health effects. HAPs are released by mobile sources and industrial sources. Also referred to as air toxics. Related program: Clean Air Act.

Hazardous Waste
A waste which, because of its quantity, concentration, or characteristics, may be hazardous to human health or the environment when improperly treated, stored, transported, or disposed. Specific definitions of hazardous waste vary by statute or regulation.

Heavy Metals
Metallic elements with relatively high atomic weights that can contaminate ground water and

surface waters, wildlife, and food. Heavy metals have the potential to be toxic at relatively low concentrations. Examples include arsenic, cadmium, chromium, copper, lead, mercury, selenium, and zinc.

Hexachlorobenzene (HCB)
A critical pollutant once used as a pesticide for grain protection until banned by the U.S. in 1976. It is still produced as a byproduct during the manufacture of other chlorinated hydrocarbons. It is a persistent toxic substance and is found in the tissues of fish, animals, and humans from the Great Lakes basin. Limited uses of HCB are still permitted. Related program: Binational Program.

House Great Lakes Task Force
A bipartisan coalition of U.S. Representatives from Great Lakes states that works to advance the economic and environmental health of the Great Lakes region.

Human Health Criteria
These are descriptive or numeric expressions that specify how much of a pollutant can be allowed in a water body and still allow for the protection of human health. *See also* water quality criteria. Related program: Great Lakes Initiative.

Hydric Soils
Soils that are saturated, flooded, or ponded long enough during the growing season to develop anoxic conditions in the upper part of the soil profile.

Hydrocarbons
A class of compounds that contain hydrogen and carbon. This group of compounds includes the naturally occurring hydrocarbons produced by plankton, as well as many petroleum-based products like gasoline and motor oil. Chlorinated hydrocarbons, a subclass of hydrocarbons, are human derived and generally toxic.

Hydrophytic Vegetation
Plant life capable of growing in wet conditions, such as in water or in soil or other substrate that is periodically saturated with water. The presence of hydrophytic plants is one of the indicators used in wetland identification and delineation. Related programs: Wetlands Conservation Act, Wetlands Conservation Act Rules.

Individual Permit
An Army Corps of Engineers permit that is issued following a case-by-case evaluation of an application to perform dredge or fill activities in the waters of the U.S., including wetlands. Related programs: Section 404, 33 CFR.

Industrial Waste
Any liquid, gaseous, or solid waste resulting from any process of industry, manufacturing, trade, or business or from the development of any natural resource.

Inflow and Infiltration (I and I)
The penetration of water from the soil into sewer or other pipes through defective joints or connections and/or the penetration of water through the ground surface into the subsurface soil.

Institute for Lake Superior Research (ILSR)
Original name for the Large Lakes Observatory.

Intake Credits
A process that allows a point source discharger to take into account the quality of its source water when determining its effluent limitation standards.

Integrated Great Lakes Atmospheric Deposition Network (IGLADN)
A joint effort of the U.S. and Canada to measure atmospheric deposition of toxic material to the Great Lakes. It was mandated by the Great Lakes Water Quality Agreement. The network also fulfills the requirements of the Great Waters Program mandated by the 1990 Clean Air Act Amendments calling for a Great Lakes atmospheric deposition network. One master sampling station was installed at each of the Great Lakes by the end of 1991 to monitor for deposition of selected toxic pollutants, including mercury. Related program: Great Lakes National Program Office.

Integrated Pest Management (IPM)
A management system that uses all suitable techniques in an economical and ecologically-sound manner to reduce pest populations and maintain them at levels that do not have an economic impact, while minimizing danger to humans and the environment.

International Association for Great Lakes Research (IAGLR)
An international association of scientists that studies the world's large lakes. They publish a research periodical called the Journal of Great Lakes Research and hold yearly meetings within the Great Lakes basin.

International Joint Commission (IJC)
An international organization formed by Canada and the United States in 1909 as a result of the Boundary Waters Treaty to assist in preventing disputes and resolving issues involving all water bodies shared by the U.S. and Canada and to make recommendations about their management, particularly water quality issues and the regulation of water levels. Three commissioners are appointed by each country. Under the Great Lakes Water Quality Agreement, the IJC is also required to monitor progress by Canada and the United States as the two countries implement the goals and objectives of the Agreement. The IJC analyzes and publishes data, provides advice and recommendations and undertakes other initiatives as requested. Two advisory boards, the Great Lakes Water Quality Advisory Board and the Science Advisory Board, exist to assist the Commission with the Agreement-related responsibilities. Related program: Great Lakes Water Quality Agreement

Interstate Waters
Rivers, lakes, and other waters that flow across state or international boundaries. These include waters of the Great Lakes.

Invertebrates
The classification for animals that do not have a backbone or internal skeleton. *See also* zooplankton and benthic invertebrates.

Lacey Act
This act, enforced by the U.S. Fish and Wildlife Service, is designed to control environmental releases of injurious fish and wildlife. This law includes species that threaten non-agricultural interests.

Lake Carriers Association
This organization, established in 1880, represents U.S. maritime shipping companies throughout the Great Lakes. Its mission includes safe, efficient shipping procedures; Great Lakes shipping statistics; consultation on ice-breaking issues; harbor and channel dredging; sediment disposal; and environment and commerce regulations and legislation.

Lake Michigan Mass Balance Study (LMMB)
This mass balance research project begun in 1994 is part of the Lake Michigan Lakewide Management Plan and is designed to develop a sound, scientific base of information that will guide future toxic pollutant load reduction and prevention activities. Related Programs: Great Lakes Toxic Reduction Effort, Lakewide Management Plan, Clean Air Act, Clean Water Act.

Lake Superior
At the head of the Great Lakes system, Superior is the world's largest freshwater lake by surface area and long considered the cleanest and most pristine of the Great Lakes. Industrial activity, shipping, and atmospheric inputs of persistent and bioaccumulative toxic substances have raised concerns about the lake's water quality.

Lake Superior Basin
Used to describe Lake Superior and the surrounding watersheds emptying into the lake.

Lake Superior Binational Forum
This international program consists of a cross-section of basin stakeholders, including representatives from environmental and native groups, industries, and municipalities in the Lake Superior basin. It provides citizen input into the Binational Program concerning reductions in the use and discharge of toxic substances into the basin. The Forum identifies barriers to reductions in pollutant use and proposes alternatives for overcoming those barriers. Related Program: Binational Program

Lake Superior Binational Program to Restore and Protect the Lake Superior Basin
See Binational Program.

Lake Superior Biosphere Reserve
An international undertaking that would identify portions of the lake for special protection or study. Proposals to create a binational Lake Superior Biosphere Reserve as part of the United Nations Man and the Biosphere program are under review by the United States and Canada.

Lake Superior Center (LSC)
An education/exhibition facility on freshwater systems and Lake Superior, located in Duluth, Minnesota. Home of Superior Lakewatch.

Lake Superior Lakewide Management Plan (LaMP)
A binational plan to address threats to the Lake Superior ecosystem. The LaMP embodies a

systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses. It is being developed in four stages. LaMP Stages 1 and 2 have been completed for the chemical portion of the LaMP. The Stage I LaMP (completed in September 1995) applies only to the nine designated critical pollutants from the zero discharge demonstration program for point source discharges. The Stage 2 LaMP (completed in July 1999) sets remediation goals or load reduction schedules for the nine virtual elimination pollutants identified in the Stage 1 LaMP. The Stage 3 LaMP (released for public comment in November 1999) selects pollutant load reduction strategies and remedial actions with respect to the nine virtual elimination pollutants. LaMP 2000 reflects the state of knowledge and progress of the LaMP at that time. The LaMP process will be an iterative process from 2000 forward and the LaMP will be updated biennially. *See also* State of the Lake Superior Basin Reporting Series. Related programs: Great Lakes Water Quality Agreement, Binational Program.

Lake Superior Partnership
A partnership between the state of Minnesota and the Western Lake Superior Sanitary District in Duluth that conducts multi-media inspections to insure compliance and identify pollution prevention opportunities for dischargers.

Lake Superior Pollution Prevention Strategy (P2 Strategy)
A federal/state action plan consisting of recommendations for achieving the goal of eliminating pollution at its source and evaluating recycling, treatment, and disposal options where source reduction is not possible. The focus of the Pollution Prevention Strategy is the nine critical pollutants identified by the Zero Discharge Demonstration Program. Commonly called the P2 strategy. Related programs: Binational Program, Great Lakes National Program Office.

Lake Superior Pollution Prevention Team
An organization that developed the Lake Superior Pollution Prevention Strategy. The team is made up of regulatory staff from Minnesota, Michigan, Wisconsin, and the Great Lakes National Program Office. Related program: Binational Program.

Lake Superior Project
An EPA-administered program that establishes a strategy and implementation plan for pollution prevention technical assistance for small and medium-sized businesses in the Lake Superior basin. Related program: Council of Great Lakes Governors.

Lake Superior Research Institute (LSRI)
A University of Wisconsin-Superior center that conducts research and education specifically on Lake Superior. Originally called the Center for Lake Superior Environmental Studies. Related program: University of Wisconsin-Superior.

Lake Superior Task Force
An international organization made up of the senior managers who developed the Binational Program to Restore and Protect Lake Superior and who continue to provide direction to the Superior workgroup of the Binational Program.

Lakewatch Program
See Superior Lakewatch.

Lakewide Management Plan (LaMP)
The binational programs called LaMPs provide a process for coordinating and prioritizing activities designed to reduce loadings of critical pollutants. The emphasis is on identifying the major sources of these pollutants and concentrating regulatory efforts where they will have the most impact. LaMPs are being developed for each of the Great Lakes. *See also* Lake Superior LaMP.

Large Lakes Observatory (LLO)
This University of Minnesota organization established in 1994 supports and performs research on large lakes of the world, including Lake Superior. It was formerly called the Institute for Lake Superior Research. Related program: University of Minnesota.

Leachate
The contaminated liquid resulting from water seeping through a landfill or other materials. Chemicals such as fertilizer are leached from the soil when rainwater travels through the soil.

Legislative Commission on Minnesota Resources (LCMR)
The LCMR recommends funding for natural resource programs to be financed by the Minnesota Future Resources Fund, the Minnesota Environment And Natural Resources Trust Fund, and Federal Oil Overcharge Funds. Funds have been used for a number of projects related to Lake Superior, such as public boat access improvement.

Lethal Concentration 50% (LC50)
A statistically or graphically estimated concentration that is expected to be lethal to 50% of a group of organisms under specified conditions.

Lethal Dose 50% (LD50)
A statistically or graphically estimated dose that is expected to be lethal to 50% of a group of organisms under specified conditions.

Levels Reference Study
A report that suggested methods to alleviate the adverse consequences of fluctuating water levels in the Great Lakes-St. Lawrence River System. The Levels Reference Study Board, appointed by the International Joint Commission, completed the report in 1993 after an intensive public involvement process in the U.S. and Canada.

Limited Resource Value Waters
Surface waters in Minnesota which are of limited value as a water resource and where water quantities are intermittent. These waters are protected to allow secondary body contact use, to preserve the ground water for use as a drinkable water supply, and to protect aesthetic qualities of the water. Related program: Minnesota Rule Chapter 7050.

Limnology
The scientific study of freshwater, especially the history, geology, biology, physics, and chemistry of lakes.

Load
An amount of water, sediment, nutrients, pollutants, heat, etc. that is introduced into a receiving

water. Loading may be either of anthropogenic origin (pollutant loading) or natural (natural background loading). Related programs: Water-related Code of Federal Regulations (parts in chapter 40 of the CFR), Clean Water Act, MN Rule Chapter 7050.

Load Allocation (LA)
The portion of a receiving water's load capacity that is attributed either to nonpoint sources of pollution or to natural background sources. Load allocations are best estimates depending on the availability of data and prediction techniques. Wherever possible, natural and nonpoint source loads are distinguished. Related program: Water-related Code of Federal Regulations (parts in chapter 40 of the CFR).

Load Capacity
The greatest amount of load that a water body can receive without violating water quality standards. Related programs: Water-related Code of Federal Regulations (parts in chapter 40 of the CFR), federal and state statutes.

Local Governmental Unit (LGU)
A county board, joint county board, watershed management organization, watershed district or a township, or city. Related programs: Wetlands Conservation Act, Wetlands Conservation Act Rules.

Lowest Observable Effect Concentration (LOEC)
For toxic substances, it is the lowest tested concentration at which adverse effects are observed in aquatic organisms at a specific time of observation.

Macrophytes
This term literally means "large plant." Usually refers to rooted, seed-producing aquatic plants.

Management Measures (MM)
A management measure is an economically achievable way to control the addition of pollutants from existing and new nonpoint sources. These measures call for the best available nonpoint pollution control practices, technologies, processes, site specific criteria, operation methods, or other alternatives. Related programs: Coastal Zone Management Act, Clean Water Act.

Mass Balance
A scientific approach that studies the sources, movement, and destination of any substance, for example a contaminant, that enters a lake system. A mass balance budget for a particular pollutant is the amount that enters a lake minus the amount that is tied-up in the sediment, broken down by chemical or biological processes, or removed by some other means. This should equal the amount that flows out of the lake system. This exercise enables scientists to assess the possible long-term effects of a pollutant and possible remediation actions. *See also* Lake Michigan Mass Balance Study. Related programs: Great Lakes Toxic Reduction Effort, Lakewide Management Programs.

Mercury (Hg)
A heavy metal, mercury is a neurotoxin that is toxic if breathed or ingested at sufficiently high concentrations. Mercury is present naturally in the environment. It has commonly been used in a wide variety of applications including thermometers, fluorescent bulbs, mirrors, hide

preservation, paints, plastic coloring, inks and stains, and golf course pesticides. Because of its common use, mercury is released during garbage incineration. It is also released through the combustion of fuels such as coal and wood for energy production. Mercury readily bioaccumulates in all aquatic organisms, especially fish and shell fish and in humans and wildlife that consume fish. Many lakes in the Great Lakes region have fish consumption advisories due to high levels of mercury primarily caused by atmospheric deposition. Mercury is one of the nine critical pollutants addressed by the Lake Superior LaMP. Related program: Binational Program.

Mesotrophic
A term used to describe a lake of moderate primary productivity. *See also* eutrophic and oligotrophic.

Mid-Continent Ecology Division (MED)
The EPA's freshwater ecology and water pollution research laboratory in Duluth, Minnesota. Established in 1967, the lab develops methods for predicting and assessing the effects of pollutants on freshwater resources. It is also involved in Great Lakes research, such as work in food chain contaminants, modeling, coastal wetlands, and the Environmental Monitoring and Assessment Program. MED was formerly called the Environmental Research Lab-Duluth. Related program: Environmental Protection Agency.

Minnesota Acid Deposition Control Act
A Minnesota law passed in 1982 that required the MPCA to (1) identify the areas of the state containing resources sensitive to acid deposition, (2) develop a standard to protect these resources, (3) adopt a control plan to reduce sulfur dioxide emissions, and (4) ensure that all Minnesota emission sources subject to the control plan were in compliance by January 1, 1990.

Minnesota Air Toxics Strategy
A program developed by the Minnesota Pollution Control Agency to help achieve smooth, fair implementation of air toxics provisions of the 1990 Clean Air Act Amendments, protection of public health and the environment, and the collection of air toxics information. The strategy mirrors the federal program somewhat, but has not gone through rule-making. It is a shift in focus for the state away from air toxics rules.

Minnesota Department of Health (MDH)
The state agency responsible for human health protection in Minnesota. Among other duties, the MDH prepares the fish consumption advisory each year and establishes drinking water standards.

Minnesota Department of Natural Resources (MN DNR, DNR)
A Minnesota state agency responsible for the management of the state's timber, waters, minerals, and wildlife. The Department is organized by division according to the resources it manages: forestry, fish and wildlife, parks and recreation, minerals, trails and waterways, enforcement, and waters.

Minnesota Environmental Response and Liability Act (MERLA)
This Minnesota state legislation was patterned after the Comprehensive Environmental Response, Compensation, and Liability Act, and provides the state with the authority to deal with uncontrolled releases of hazardous substances to the environment (MN Statute 115B).

Minnesota Interagency Exotic Species Task Force Committee
Established by Minnesota state legislation in 1989, this task force established a state-wide communications network between agencies that are involved with regulations, management, research, technical assistance, public awareness, and educational programming regarding potential and existing exotic species.

Minnesota Pollution Control Agency (MPCA, PCA)
A Minnesota state agency responsible for setting standards and authorizing permits for air quality, solid waste, hazardous waste disposal, water quality, and noise pollution. The focus of the MPCA is on compliance to these standards through technical assistance, education, and information. The agency is organized into four major divisions: air quality, water quality, ground water and solid waste, and hazardous waste.

Minnesota Rule Chapter 6280
A Minnesota rule that requires permits for activities which are meant to control aquatic plants and submerged vegetation. These rules are administered by the MN DNR.

Minnesota Rule Chapter 7001
A Minnesota state regulation that contains the permit process and permit requirements for hazardous waste facilities, National Pollutant Discharge Elimination System, and water quality certification (Section 401 Certification). This regulation is administered by the MPCA. Related program: Clean Water Act.

Minnesota Rule Chapter 7007
A Minnesota state regulation that contains requirements for a facility to obtain an air emission facility permit. It is administered by the MPCA. Related program: Clean Air Act.

Minnesota Rule Chapter 7009
A Minnesota state regulation that contains the state ambient air quality standards and methods of measurement to meet those standards. The programs are administered by the MPCA. Related program: Clean Air Act.

Minnesota Rule Chapter 7021
The Minnesota rule that includes the acid deposition standard and control requirements which apply to the electric power generating utilities. Also known as the Minnesota Acid Deposition Control Rule. The rule is administered by the MPCA. Related program: Clean Air Act.

Minnesota Rule Chapter 7050
A Minnesota rule that sets standards for protecting the quality and purity of the waters of the state. These standards are administered by the MPCA. Related program: Clean Water Act.

Minnesota Rule Chapter 7060
A Minnesota rule that protects and preserves the underground waters of the state. This rule is administered by the MPCA.

Minnesota Rule Chapter 8420
A Minnesota rule that identifies replacement plan criteria for wetland drain and fill activities

which require mitigation under the Wetland Conservation Act. These rules are administered by the Board of Water and Soil Resources. Related program: Wetland Conservation Act Rules.

Minnesota Sea Grant (Sea Grant)
This University of Minnesota-based program supports research, extension, and education about Lake Superior, the other Great Lakes, and inland waters of Minnesota, making research accessible to citizens, resource managers, and policy makers. Related programs: National Oceanic and Atmospheric Administration, National Sea Grant College Program.

Minnesota Toxic Pollution Prevention Act (TPPA)
State legislation passed into law in 1990, this act creates policies and sets up ways to prevent the release of toxic pollutants into the environment by reducing or eliminating toxic pollutants at their source through pollution prevention.

Mitigation
See wetland mitigation.

Mixing Zone
A limited area or volume of water where initial dilution of a point source pollutant discharge takes place. The zone is extended to cover the secondary mixing in the surrounding waterbody. Numeric water quality criteria can be exceeded, but acutely toxic conditions are prevented from occurring in this zone. Related programs: Clean Water Act, National Pollutant Discharge Elimination System.

Multi-media Inspections
These are inspections of a discharger's effect on water and air quality and the generation of solid waste. Related program: Western Lake Superior Sanitary District.

Multi-media Risk
The human health risk due to exposure to a pollutant through all pathways, such as inhalation, ingestion, or skin contact.

Municipal Industrial Strategy for Abatement (MISA)
A program initiative of the province of Ontario intended to reduce water pollution.

Mutagen
A substance that is known or suspected to cause mutations.

Mutation
A permanent change in the hereditary material involving a physical change in chromosomes or genes.

Nation's Waters
See Waters of the United States.

National Ambient Air Quality Standards (NAAQS)
Standards that EPA sets under the Clean Air Act to protect public health with an adequate margin of safety (primary standards) and to protect the environment (secondary standards). These

standards apply to sources that emit pollutants into the atmosphere. Related program: Clean Air Act.

National Environmental Policy Act (NEPA)
A federal law passed in 1990 that promotes efforts to prevent or eliminate damage to the environment and biosphere and stimulates the health and welfare of people. It established a Council on Environmental Quality. It is comprised of two Titles: Title I - Declaration of National Environmental Policy; Title II - Council on Environmental Quality.

National Oceanic and Atmospheric Administration (NOAA)
A federal agency, NOAA's mandate is to conserve and manage wisely the nation's coastal and marine resources, and describe and predict changes in the earth's environment to ensure sustainable economic opportunities. NOAA administers the National Sea Grant College Program, National Underseas Research Program, National Marine Fisheries Service, National Coastal Resources Research and Development Institute, National Weather Service, and others.

National Park Service (NPS)
An agency of the U.S. Department of the Interior that manages the national park system. Active participant in the Binational Program.

National Pollutant Discharge Elimination System (NPDES)
Federal regulations that constitute the national program for issuing, modifying, revoking, re-issuing, terminating, monitoring and enforcing permits, and enforcing pretreatment requirements for point source discharges to surface waters under the Clean Water Act, Section 402. Related programs: Clean Water Act, 40 CFR.

National Priorities List (NPL)
A list of inactive, hazardous waste sites designated under Superfund as needing long-term remedial actions. Currently, there are about 1,200 sites on the NPL. Related program: Comprehensive Environmental Response, Compensation, and Liability Act.

National Sea Grant College Program (NSGCP)
A nation-wide partnership with public and private sectors combining research, education, and technology transfer for public service. A national network of universities meeting changing environmental and economic needs of people, industry, and government in coastal, ocean, and Great Lakes states. The program is administered by National Oceanic and Atmospheric Administration. *See also* Minnesota Sea Grant. Related program: National Oceanic and Atmospheric Administration.

Nationwide Permit (NWP)
A type of general permit issued by the Army Corps of Engineers allowing certain activities to take place in the waters of the U.S. If certain conditions are met, the specified activities can take place without the need for an individual or regional permit. Related programs: Section 404, 33 CFR.

Natural Resources Conservation Service (NRCS)
A federal agency within the United States Department of Agriculture that provides technical assistance to land users in cooperation with other federal, state, and local agencies in carrying out

a variety of natural resources-related programs designed to promote protection and wise use of these resources on private lands. Formerly the Soil Conservation Service.

Natural Resources Research Institute (NRRI)
A University of Minnesota research institute established in 1983 by the Minnesota legislature to foster economic development of Minnesota's natural resources in an environmentally-sound manner and promote private sector employment. *See also* Center for Water and the Environment. Related program: University of Minnesota.

Naturalized Species
An intentionally or unintentionally introduced species that has adapted to and reproduces successfully in its new environment. Some Great Lakes examples include the rainbow smelt, the alewife, and some salmon and trout species.

Navigable Waters
Navigable waters of the United States are waters subject to the ebb and flow of the tide and/or used to transport interstate or foreign commerce. Once the determination of navigability is made, it applies over the entire surface of the water body, and is not changed by later actions or events which impede or destroy navigable capacity. Also referred to as waters of the U.S. Related program: 33 CFR.

Neurotoxin
A substance that is known or suspected to be poisonous to nerve tissue.

Nitrogen Oxides (NOx)
Pollutants that can be a component of smog and also can contribute to acid rain. One of the criteria pollutants regulated by the 1990 Clean Air Act Amendments. Sources include automobiles and industrial point sources.

No Net Loss
A federal and Minnesota state policy to achieve no overall net loss of the nation’s remaining wetlands base as defined by acreage and function and to restore and create wetlands where feasible, to increase the quality and quantity of the nation’s wetland resource base. Related programs: Wetland Conservation Act, Section 404.

No Observable Effect Concentration (NOEC)
For toxic substances, it is the highest tested concentration at which no adverse effects are observed in an aquatic organism at a specific time of observation.

Non-Chemical Stressors
Physical and biological factors that can impact water quality or ecosystem health. Examples include heat, sediment, and non-indigenous species.

Non-Indigenous Aquatic Nuisance Prevention and Control Act of 1990
A federal law to prevent the unintentional introduction and dispersal of non-indigenous species into the waters of the U.S. The act mandates the establishment of: a national ballast water control program; the Aquatic Nuisance Species Task Force; initial research funding; technical assistance and education for federal and state agencies; state management plans; and grant

programs to prevent, monitor, and control the spread of zebra mussels and other exotic species. It also provides for the establishment of regulations that control the introduction of and dispersal of these organisms. *See also* aquatic nuisance species.

Non-Indigenous Species
Those species found beyond their natural ranges or natural zone of potential dispersal. Also referred to as exotic species. *See also* aquatic nuisance species.

Nonpoint Source
See nonpoint source pollution.

Nonpoint Source Pollution (NPS)
Pollution where the sources cannot be traced to a single, distinct, identifiable point. Nonpoint source pollution can come from atmospheric deposition, erosion, and runoff from parking lots, farms, and streets.

North Shore Management Board (NSMB)
A Minnesota joint powers board that represents local governments in decisions about coastline management on Minnesota's north shore. The board implements the North Shore Management Plan.

North Shore Management Plan (NSMP)
A Minnesota plan for the environmental protection and orderly growth of the north shore of Lake Superior developed by the residents of the area. Consists of several planning elements, each dealing with an area needing special attention, such as shoreland management, harbors of refuge, transportation, recreation, tourism, and economic development.

Northeast Minnesota Waste Exchange (NMWE)
A local program administered by the Western Lake Superior Sanitary District, this organization recycles household waste such as paint. Its primary effort is aimed at getting businesses that have unwanted products in touch with potential users of those products. Related program: Western Lake Superior Sanitary District.

Northeastern Minnesota Environmental and Economic Council (NEMEEC)
An organization of northeastern Minnesota citizens formed in the 1970's in response to the potential for Minnesota's enrollment in the federal Coastal Zone Management Program. NEMEEC's approach is to ensure that CZM does not ignore or hamper economic development.

Nutrients
Elements or compounds essential as raw materials for organism growth and development, such as carbon, nitrogen, and phosphorus.

Octachlorostyrene (OCS)
A toxic substance and critical pollutant that is a by-product of high temperature industrial processes involving chlorine. Like dioxin, OCS is not produced intentionally. Release to the environment occurs in effluent from chlorine and gas production, aluminum smelting, and other metal production. OCS has been found in leachate from industrial landfills and fly ash from waste incinerators. Related program: Binational Program.

Oligotrophic
Refers to an unproductive, nutrient poor lake that typically has very clear water. Lake Superior is classified as an ultra-oligotrophic lake.

Ontario Federation of Anglers and Hunters (OFAH)
An Ontario conservation organization that promotes sustainable use of natural resources by providing boater education programs on exotic species, fish, wildlife, forestry research and management, and timber management policy.

Ontario Ministry of Natural Resources (OMNR)
This provincial agency is responsible for management of Canadian waters of the Great Lakes to help sustain a healthy ecosystem. Responsibilities of the OMNR include: coordinating resource planning with other entities; protecting and enhancing biological resources; managing fish harvest; protecting and rehabilitating habitat and fish communities; enforcing legislation; increasing public awareness of exotic species through educational programming; and monitoring ecosystem health through assessment and research programs.

Ordinary High Water Mark (OHW)
The elevation marking the highest water level which has been maintained for a sufficient time to leave evidence upon the landscape. Defined in Minnesota statutes as the boundary of protected waters. Generally, it is the point where the natural vegetation changes from predominately aquatic to upland species. For streams, the OHW is generally the top of the bank of the channel. The OHW is the elevation from which building and sewage setbacks are measured. OHWL means the ordinary high water level.

Organic Chemicals
Nearly all of the millions of compounds that contain carbon atoms are organic chemicals. More than 90% of all known compounds are organic. The few carbon compounds that are not considered organic include carbon dioxide and bicarbonate. Hydrocarbons like methane are simple organic chemicals that contain only hydrogen and carbon. Other organic chemicals include most pesticides and chemicals based on benzene.

Outfall
The location or structure where wastewater or drainage empties into the surface water from a sewer, drain, or other conduit.

Outstanding International Resource Waters (OIRW)
This proposed designation by the Binational Program and the Great Lakes Initiative would protect the entire Lake Superior basin from new or expanded point source discharges of persistent toxic substances.

Outstanding National Resource Waters (ONRW)
This proposed designation contained in the Clean Water Act Reauthorization would establish special areas within the U.S. portion of the Lake Superior basin where new or expanded point source discharges of persistent toxic substances would be prohibited as part of the Binational Program and Great Lakes Initiative. *See also* MN Rule Chapter 7050. Related program: Clean Water Act.

Outstanding Resource Value Waters (ORVW)
Waters of the state of Minnesota with high water quality, wilderness characteristics, unique scientific or ecological significance, exceptional recreation value, or other special qualities that warrant stringent protection from pollution. *See* MN Rule Chapter 7050.

Ozone
A pollutant formed in the lower atmosphere by the reaction of nitrogen oxides and hydrocarbons in sunlight, commonly called smog, for which National Ambient Air Quality Standards have been established. Ozone is also found naturally in the upper atmosphere where it acts as a protective filter, screening out ultra-violet rays.

PAHs
See Polycyclic Aromatic Hydrocarbons.

Part 70 Permit
A federal regulation that defines the requirements for permitting facilities for air emissions. States with federally-approved permit programs administer the permitting of facilities within their state. Related programs: Minnesota Rule Chapter 7007, 1990 Clean Air Act Amendments.

Particulates
Very small separate particles composed of organic or inorganic matter.

Parts per Billion (ppb)
The number of parts of a substance per billion parts of another substance into which it is combined. Often expressed as micrograms per liter for water and micrograms per kilogram for fish and sediments.

Parts per Million (ppm)
The number of parts of a substance per million parts of another substance into which it is combined. Often expressed as milligrams per liter water or milligrams per kilogram for fish tissue and sediments.

Parts per Thousand (ppt)
The number of parts of a substance per thousands parts of another substance into which it is combined. Often expressed as grams per liter of water or grams per kilogram for fish tissue and sediments.

Periphyton
Algae that grow attached to surfaces such as rocks or larger plants.

Persistent Toxic Substance
A toxic pollutant that remains in the environment for a substantial period of time, potentially causing injury to ecosystem health.

pH
A numeric value that indicates relative acidity and alkalinity on a scale of 1 to 14. A pH of 7.0 is neutral, higher values indicate increasing alkalinity; lower values indicate increasing acidity.

Phytoplankton
Algae that grow suspended in the water column or open waters of a lake.

Plankton
A term used to describe bacteria, tiny plants (phytoplankton), and animals (zooplankton) that live in the water column of lakes.

Point Source
See point source pollution.

Point Source Pollution
Pollution from a distinct, identifiable source, such as a pipe, smokestack, or exhaust.

Pollutant
Chemicals or refuse material released into the atmosphere, water, or onto the land.

Pollution Prevention (P2)
This is defined in the Minnesota Toxic Pollution Prevention Act as eliminating or reducing at the source the use, generation, or release of toxic pollutants. Methods of reducing pollution include, but are not limited to, industrial process modification, inventory control measures, feedstock substitutions, various housekeeping and management practices, and improved efficiency of machinery. The federal version of this term is source reduction.

Pollution Prevention Act of 1990
A federal law that establishes a national policy of pollution prevention, and requires the EPA to develop and implement a strategy to promote source reduction. This act declares as national policy that pollution prevention is the preferred approach to environmental protection.

Polychlorinated Biphenyls (PCBs)
One of the nine critical pollutants, PCBs are a group of over 200 nonflammable compounds formerly used in heating and cooling equipment, electrical insulation, hydraulic and lubricating fluids, and various inks, adhesives, and paints. These compounds are highly toxic to aquatic life, persist in the environment for long periods of time, and are bioaccumulative. PCBs are suspected carcinogens, and are linked to infant development problems. Fish from some lakes and streams in Minnesota contain measurable amounts of PCBs. *See also* Fish Consumption Advisory. Related program: Binational Program.

Polycyclic Aromatic Hydrocarbons (PAHs)
A family of organic chemicals based on the chemical structure of benzene which result from incomplete combustion of organic chemicals and are associated with grease and other components derived from petroleum byproducts. Some examples of the many PAH compounds include: benzo(a)anthracene, benz(b)fluoranthene, benzo(a)pyrene, chrysene, phenanthrene, and pyrene.

Pretreatment
Partial wastewater treatment required for some industries. Pretreatment removes some types of industrial pollutants before the wastewater is discharged to a municipal wastewater treatment plant.

Primary Productivity
The amount of production of living organic material through photosynthesis by plants, including algae, measured over a period of time.

Primary Treatment
The first step in wastewater treatment in which most of the debris and solids are removed mechanically.

Priority Pollutants
Pollutants identified in certain federal and state regulations. Priority pollutants have different definitions in air, water, and waste programs.

Program Office
See Great Lakes National Program Office.

Protected Waters
Minnesota waters of the state identified as public waters or wetlands under Minnesota statutes.

Public Waters
Generally, public waters are water bodies determined by Minnesota statutes to have significant public value. They are controlled by the state.

Public Waters Wetlands
A class of wetlands defined by the state of Minnesota as public waters deserving of a certain level of protection under the Wetland Conservation Act. These include all Types 3, 4, and 5 wetlands, as defined in U.S. Fish and Wildlife Service Circular No. 39 (1971 edition), that are ten or more acres in size in unincorporated areas, or 2-1/2 or more acres in size in incorporated areas.

Publicly Owned Treatment Works (POTW)
Any device or system that is used in treatment, including recycling and reclamation, of municipal sewage. Related programs: Clean Water Act, 40 CFR.

Purple Loosestrife
A wetland plant from Eurasia that quickly invades water bodies, including the Great Lakes, forming dense stands unsuitable as cover, food, or nesting sites for fish, amphibians, waterfowl, and wildlife. Imported as an ornamental plant, it spread quickly across North America along roads, canals, and drainage ditches. Research on the use of European beetles that attack only purple loosestrife shows promise for biological control in North America.

Quagga Mussel
A close cousin to the zebra mussel, this exotic mussel was brought into the Great Lakes in the ballast water of transoceanic ships and is expected to have impacts similar to those of the zebra mussel. Although some evidence suggests that it prefers the deeper waters of the Great Lakes, it has, like the zebra mussel, quickly infested inland river systems. The name quagga comes from an extinct member of the zebra family.

Receiving Waters
Rivers, streams, lakes, or any body of water into which wastewater is discharged.

Region 5
The EPA's regional office that covers Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin. Related program: Environmental Protection Agency.

Regional Environmental Monitoring and Assessment Program (REMAP)
Environmental Monitoring and Assessment Program work on a regional scale. The St. Louis River is a Great Lakes example of a REMAP study. Cooperators include MED, GLNPO, NRRI, MPCA, UWS, and EPA Region 5. Related programs: Environmental Protection Agency, Environmental Monitoring and Assessment Program.

Regional Permit
A type of general permit that may be issued by a division or district engineer (Army Corps of Engineers), after compliance with other procedures, for activities in navigable waters of the U.S. or wetlands. Related programs: Section 404, 33 CFR.

Regulation
Rules that outline specific procedures developed by federal or state agencies which are used to implement laws.

Remedial Action Plan (RAP)
These are federally-mandated local plans designed to restore environmental quality to Areas of Concern on the Great Lakes (there are 8 in Lake Superior and there were initially 43 throughout the Great Lakes). The Areas of Concern were identified for their persistent pollution problems. Remedial Action Plans were called for by a protocol added to the Great Lakes Water Quality Agreement in 1987. Related program: Great Lakes Water Quality Agreement.

Report to Congress on Toxic Air Deposition to the Great Waters
See Great Waters Study.

Residence Time
The time required for a water body to exchange its entire volume of water. Lake Superior takes about 173 to 191 years to flush its entire volume. This is an important factor used in determining the residence time of toxic pollutants in the lake. Also referred to as flushing time.

Resource Conservation and Recovery Act (RCRA)
A federal law that established a comprehensive cradle-to-grave system for regulating hazardous waste.

Riparian Area
Vegetated ecosystems found along any stream or river. These areas characteristically have a high water table and are subject to periodic flooding and influence from the adjacent water body.

Riprap
Rock or other large material that is placed to protect streambanks or lakeshores from erosion due to runoff or wave action.

Risk Assessment
A complex process by which scientists determine the harm that a substance, activity, lifestyle, or

natural phenomenon can inflict on human health or the environment. The process involves analyzing scientific data to describe the form, dimension, and characteristics of risk. Assessments are usually predictive estimates of how risky a particular situation is. *See also* risk management, ecological risk assessment, comparative risk analysis.

Risk Management
The process by which risk assessment results are used with other information to make regulatory decisions. Risk management asks, "What shall we do about this risk?" *See also* risk assessment and ecological risk assessment.

Risk Reduction
Anything, such as education, regulation, or remediation, that reduces the adverse effects of exposure to risks from a substance, activity, lifestyle, or natural phenomenon.

Rivers and Harbors Act of 1899
A federal statute that allows the Army Corps of Engineers to regulate the creation of obstructions and filling of navigable waters of the U.S.

River Watch
A citizen-based volunteer water monitoring, education, and outreach program on Lake Superior sponsored by the EPA. The primary emphasis of the program is to work with secondary school teachers and students to incorporate River Watch concepts into existing course curricula. *See also* St. Louis River Watch.

Ruffe
See Eurasian ruffe.

Ruffe Control Plan
The Ruffe Control Task Force Committee (appointed by the Aquatic Nuisance Species Task Force) developed this integrated plan encompassing the legal requirements mandated by the Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990 to control the Eurasian ruffe. The program provides assessment and control measures including range reduction by chemical treatments, prevention of ballast water transport, and monitoring and surveillance. The plan also emphasizes research and public education as essential components of a ruffe control effort.

Ruffe Control Task Force Committee
An organization representing academic, business, shipping, fisheries management, and fishing interests Great Lakes-wide that developed a five-part plan aimed at controlling the spread of ruffe to western Lake Superior. Chaired by the U.S. Fish and Wildlife Service, this task force was established in 1991 by the Great Lakes Fisheries Commission.

Rule
See Regulation.

St. Louis River Management Plan
A local management plan developed by the St. Louis River Board to provide adequate protection to the Whiteface, Cloquet, and St. Louis rivers ecosystems in the areas of land use, forestry management, and land acquisition. Once implemented, the plan will result in increased lot sizes,

a no-cut zone along the river corridor, mandated forestry management plans, and public purchase of 22,000 acres of river front land. Also known as the St. Louis, Cloquet, Whiteface Corridor Management Plan.

St. Louis River Remedial Action Plan (St. Louis River RAP)
A two-state (MN and WI) group representing industry, environmental groups, academic institutions, government, researchers, and community leaders coordinated by the MPCA and WDNR. The goal is to develop a plan to combat pollution sources and to protect natural areas on the St. Louis River, an Area of Concern and the largest U.S. tributary to Lake Superior. Related program: Remedial Action Plan.

St. Louis Riverwatch
A citizen-based water quality monitoring, outreach, and education program administered by the MPCA. Students and teachers from the communities along the river conduct water chemistry tests and survey the benthic invertebrate community as well as monitor frog populations and sediment toxicity. *See also* River Watch.

Science Advisory Board (SAB)
A binational advisory group that provides advice on the adequacy of Great Lakes science and research to the International Joint Commission and the Water Quality Board. The board is responsible for developing recommendations on all matters related to research and the development of scientific knowledge pertinent to the identification, evaluation, and resolution of current and anticipated problems related to Great Lakes water quality. Related programs: Great Lakes Water Quality Agreement, International Joint Commission.

Scientific and Natural Areas (SNA)
These are areas set aside to preserve the ecological diversity of Minnesota's natural heritage. They include landforms, fossil remains, plant and animal communities, rare and endangered species or other biotic features and geologic formations. The areas are preserved for scientific study and public edification as components of a healthy environment. The program is administered by the MN DNR, Division of Fish and Wildlife.

Sea Grant
See Minnesota Sea Grant and National Sea Grant College Program.

Sea Lamprey
An exotic, eel-like animal that attaches to fish with a sucking disk and sharp teeth. A native of the Atlantic Ocean, the lamprey made its way into all the Great Lakes following the opening of the Welland Canal in 1829 and its deepening in the 1900’s. By the 1930’s, sea lamprey were found in all of the Great Lakes. During the 1940’s and 1950’s, lamprey caused the collapse of lake trout, whitefish, and chub populations in all the Great Lakes with the exception of Lake Superior. It has been estimated that one sea lamprey can kill up to 40 pounds of lake trout during its lifespan. *See also* Sea Lamprey Control Program.

Sea Lamprey Control Program
The U.S. Fish and Wildlife Service and the Department of Fisheries and Oceans in Canada work together, under the direction of the Great Lakes Fishery Commission, to minimize sea lamprey

populations in the Great Lakes. Lamprey are controlled by applying a selective toxicant, TFM, to streams during the lamprey's most vulnerable life stage. Other control techniques include barriers, pheromone release, and sterilization of male lamprey.

Seaway Port Authority of Duluth
The Authority, consisting of seven members representing state, county, and city (Duluth) interests, promotes growth of international and domestic maritime commerce for Minnesotas World Port, and strives to strengthen the financial condition of the Port while enhancing the regional economy through industrial development and construction of port facilities. The Authority co-sponsored, along with the Lake Carriers Association, the Voluntary Ballast Water Exchange Plan for the Control of Ruffe in Lake Superior.

Secchi Disk Depth (SDD)
An estimate of the transparency of a lake, obtained by lowering a small (20 cm) disk into the water until it is no longer visible and noting the depth at which it disappears from view. Oligotrophic lakes are typically more transparent (and have a greater Secchi depth) than more productive, or eutrophic lakes. *See also* Superior Lakewatch.

Secondary Treatment
The second step in most publicly-owned treatment systems, where bacteria consume the organic parts of the waste.

Section 10
Refers to Section 10 of the federal Rivers and Harbors Act of 1899.

Section 118
A term used to refer to Section 118 of the federal Clean Water Act that identifies program requirements for the Great Lakes. Related program: Clean Water Act.

Section 305 (b)
The term refers to Section 305 (b) of the federal Clean Water Act, which requires a report on the status of fishable, swimmable waters. The states submit a biennial report to the EPA, which compiles the reports into a report to Congress. Related program: Clean Water Act.

Section 319
A term used to refer to Section 319 of the federal Clean Water Act that identifies the program requirement for nonpoint source management programs. Related program: Clean Water Act.

Section 401
A term used to refer to Section 401 of the federal Clean Water Act which requires water quality certification by the appropriate state agency, for example, the Minnesota Pollution Control Agency. Under Section 401, no federal permit to discharge pollutants into the waters of the U.S. is valid unless the state where the discharge occurs grants or waives its right to certify that the permit will not violate the state water quality standards. A federal agency cannot issue a permit when the state has denied water quality certification. Related program: Clean Water Act.

Section 402
A term used to refer to Section 402 of the federal Clean Water Act that identifies permit

requirements for point source discharges, known as the National Pollutant Discharge Elimination System. Related program: Clean Water Act.

Section 404
A term used to refer to Section 404 of the federal Clean Water Act that outlines permit requirements for dredging and other filling activities in waters of the U.S.. This is the primary federal law that regulates activities affecting wetlands. The Section 404 program is administered by the Army Corps of Engineers in accordance with the EPA. Related program: Clean Water Act.

Section 6217
A federal regulation that is a part of the Coastal Zone Act Reauthorization Amendments of 1990 entitled, Protecting Coastal Waters. This provision requires states with Coastal Zone Management Programs that have received federal approval under Section 306 of the Coastal Zone Management Act, to develop and implement Coastal Nonpoint Pollution Control Programs. These programs are to be used to control sources of nonpoint pollution which impact coastal water quality. Related programs: Coastal Zone Act Reauthorization Amendments of 1990, Coastal Zone Management Act.

Sediments
Soil particles that are or were at one time suspended in and carried by water as a result of erosion and/or resuspension. The particles are deposited in areas where the water flow is slowed such as in harbors, wetlands, and lakes.

Seiche
Seiches are lakewide displacements of water that are wind-induced. Water pushed by the wind can pile up on shore causing noticeable increases in water depth. When the wind is reduced the water mass continues to slosh back and forth like water in a bathtub. “The Seiche” is also the name of Minnesota Sea Grant’s quarterly newsletter.

Sequencing
A term used in wetlands regulations to define a process that involves avoiding, minimizing, and mitigating impacts. Related programs: Wetland Conservation Act, Wetland Conservation Act Rules.

Shorelands
Refers to Minnesota lands located 1000 feet from the ordinary high water level of a lake, pond, or flowage, and 300 feet from a river, stream, or the landward extent of floodplains.

Shoreland Management Program
A Minnesota program administered by a local government unit that meets minimum standards and criteria for the subdivision, use, and development of the shorelands of public waters.

Sigurd Olson Environmental Institute
A regional, private, non-profit organization of Northland College in Ashland, Wisconsin. Its mission is to protect environmental quality in the greater Lake Superior region and to build a future that is ecologically, socially, and economically sustainable.

Site-Specific Criteria
Water quality criteria that have been developed to be specifically appropriate to the water quality characteristics and/or species composition at a particular location. Related programs: Great Lakes Initiative, National Pollutant Discharge Elimination System.

Soil and Water Conservation Districts (SWCDs)
Local county units of government in Minnesota that assist landowners with implementation of soil and water conservation measures and practices. Related program: Board of Water and Soil Resources.

Soil Conservation Service (SCS)
See Natural Resources Conservation Service.

Source Reduction
A term that means reducing pollution at its source. It includes management systems, technologies, and other practices which reduce or eliminate the amount of any hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment prior to recycling, treatment, or disposal. The term includes equipment or technology modifications, reformulation or redesign of products, substitution of raw materials, and improvements in housekeeping, maintenance, training, or inventory control. *See also* Pollution Prevention. Related programs: Pollution Prevention Strategy, Clean Water Act, Great Lakes Initiative.

Special Designation
As part of the Binational Program to Restore and Protect the Lake Superior Basin, governments are encouraged to make special designations which: favor zero discharge of human made toxins and protect and enhance the unique character and pristine nature of the lake basin. The U.S. policy on special designation includes enhanced anti-degradation approaches (including best available technology) for new or proposed expansions to facilities. Related program: Binational Program.

Standard
See water quality standard.

State Implementation Plan (SIP)
A state plan that sets out the process for complying with the Clean Air Act requirements. If approved by the EPA it will give the state the authority to run the federal clean air program for the state. Related program: Clean Air Act.

State of the Lake Superior Basin Reporting Series (SOTLSBRS)
A series of reports prepared by the Superior Work Group that will communicate progress on the Lake Superior Binational Program. When completed, the series will consist of 5 volumes.

- Vol I: Introduction to the Basin, Its Economy, and Its Inhabitants;
- Vol II: Lakewide Management Plan (Stages I-IV);
- Vol III: Lakewide Management Plan for Nonchemical Stressors;
- Vol IV: Ecosystem Principals and Objectives for Lake Superior; and

- Vol V: Comprehensive Management Plan to Protect the Lake Superior Ecosystem (an amalgamation of volumes I-IV).

Related programs: Lake Superior Binational Program, Great Lakes Water Quality Agreement.

State of the Lakes Ecosystem Conference (SOLEC)
A conference sponsored by Environment Canada and EPA, held every two years to review and make available information on the state of the chemical, physical, and biological integrity of the Great Lakes basin ecosystem. A major purpose of the conference is to cooperate in implementing the Great Lakes Water Quality Agreement by supporting better decision-making through improved availability of information on the condition of the living components of the system and the stresses which affect them. Working papers are prepared as background for the conference.

State Shoreland Management Plan
See Shoreland Management Program.

Statute
An enactment of the legislative body of a government that is formally expressed and documented as a law.

Storm Sewers
The underground infrastructure designed to collect storm runoff from urban areas which is typically not treated by sewage treatment facilities before being discharged into nearby surface waters. Storm sewer runoff has been found to be a major contributor to nonpoint source pollution in the Great Lakes.

Storm Water
Rainwater runoff, snow melt runoff, surface water runoff, and discharges that are collected by storm sewers. Related programs: National Pollutant Discharge Elimination System, CFRs, Minnesota Rules.

Stressor
Any chemical, physical, or biological entity that can induce adverse effects on individuals, populations, communities, or ecosystems.

Sulfur Dioxide (SO_2)
A chemical compound that when emitted to the atmosphere is considered to be a major component of acid rain. One of the criteria pollutants regulated by the 1990 Clean Air Act Amendments, SO_2 is emitted mainly by anthropogenic sources. Sources include industrial point sources, such as coal fired electric utilities.

Sunsetting
A process to restrict, phase out, and eventually ban the manufacture, generation, use, storage, discharge, and disposal of a persistent toxic substance.

Superfund
See Comprehensive Environmental Response, Compensation, and Liability Act, and Minnesota Environmental Response and Liability Act.

Superfund Amendment Reauthorization Act (SARA)
See Comprehensive Environmental Response, Compensation, and Liability Act

Superior Lakewatch
A binational organization coordinated by the Lake Superior Center, the Ontario Ministry of Environment and Energy, and the Sea Grant Offices of Michigan, Wisconsin, and Minnesota that offers volunteers the opportunity to help in monitoring the water quality of Lake Superior by measuring Secchi disk depth throughout the lake.

Superior Work Group
A binational organization that assembles technical and scientific professionals from each of the six jurisdictions (U.S. and Canada) and key national agencies surrounding Lake Superior to coordinate Binational Program implementation. Related program: Binational Program.

Surface Water
All water above the surface of the ground including, but not limited to lakes, ponds, reservoirs, artificial impoundments, streams, rivers, springs, seeps, and wetlands.

Teratogen
A substance that can cause malformation in the fetus following exposure of the mother. The malformation or abnormality may be biochemical or anatomic and be of genetic or environmental origin.

Tertiary Treatment
The advanced cleaning of wastewater that goes beyond secondary treatment. This process removes nutrients, such as phosphorus and nitrogen, and most biological oxygen demand and suspended solids.

Thermal Stratification
The layering of warmer waters over colder waters that can occur in lakes, usually in the summertime. This layering occurs because as surface waters are warmed they become less dense than the underlying colder waters.

Total Maximum Daily Load (TMDL)
TMDLs are set by regulators to allocate the maximum amount of a pollutant that may be introduced into a water body and still assure attainment and maintenance of water quality standards. Related programs: water-related CFRs and rules, federal and state statutes.

Toxaphene
One of the nine critical pollutants, toxaphene is an insecticide that was developed as a substitute for DDT. Its use is now restricted in the U.S. and Canada. Toxaphene has been detected in wildlife as far north as the Arctic and levels in Lake Superior appear to be increasing in fish and sediments. Related program: Binational Program.

Toxic Pollutant
A substance or combination of substances, including disease-causing agents, which may cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including reproductive malfunctions), or physical deformation in organisms or their offspring.

Also refers to those substances listed under Section 307(a) of the Clean Water Act. Related programs: Clean Water Act, parts of chapter 40 of the CFR.

Toxic Substances
See Toxic Pollutants.

Toxic Substances Management in the Great Lakes Basin Through the Permitting Process Agreement
A binational agreement entered into by the environmental administrators of the Great Lakes States in 1986 requiring that best available control technology be installed wherever possible on all new and existing sources of persistent air toxic pollutants which impact the Great Lakes. This agreement is pursuant to implementing the governors' Great Lakes Toxic Substances Control Agreement.

Toxicity
The inherent potential of a substance to cause adverse effects in a living organism. *See* acute toxicity and chronic toxicity.

Toxicity Test
A procedure that measures the degree of effect caused by a chemical or effluent, by exposing living test organisms to the substance. *See also* acute toxicity and chronic toxicity.

U.S. Army Corps of Engineers (ACOE)
See Army Corps of Engineers.

U.S. Ballast Water Management Regulation
Mandatory regulations, enforced cooperatively by the U.S. and Canadian Coast Guards, that prohibit a commercial trans-oceanic vessel from importing ballast water having salinity values less than 30 parts per thousand into the Great Lakes in an effort aimed at preventing further introductions of harmful exotic species.

U.S. Coast Guard (USCG)
As mandated by federal law, the Coast Guard promotes safe and efficient passage of marine and air traffic in coastal waters by providing: (1) a continuous, accurate, all-weather radio navigation service; (2) warnings of dangers and obstructions by providing visual or electronic signals, buoys, and lights; and (3) search and rescue services for commerce and recreation. They also help prevent pollution by inspecting vessels and aiding in pollution clean-up efforts.

U.S. Coast Guard Auxiliary (CGAUX)
A volunteer civilian organization established by Congress in 1939 to assist the U.S. Coast Guard in promoting safety in U.S. recreational boating.

United States Code (USC)
An abbreviation used to identify federal statutes. It is used when referring to a specific code section(s). For example, the Clean Water Act is 33 U.S.C. 1251-1387.

U.S. Department of Agriculture (USDA)
A federal agency that administers the Natural Resources Conservation Service and the U.S. Forest Service, among others.

U.S. Department of Agriculture - Animal and Plant Health Inspection Service (APHIS)
An agency that inspects incoming agriculture, livestock, and produce for disease and pest-related disease.

U.S. Environmental Protection Agency (EPA, U.S. EPA)
See Environmental Protection Agency.

U.S. Fish and Wildlife Service (USFWS)
A federal agency whose mission is to conserve, protect, and enhance the Nation's fish and wildlife and their habitats for the continuing benefit of people.

U.S. Geological Survey (USGS)
A federal agency that performs surveys, investigations, and research covering topography, geology, and the mineral and water resources of the U.S.

U.S. Geological Survey - Biological Resources Division (USGS - BRD)
A federal division within the USGS. The mission of the BRD is to provide, with others, the scientific understanding and technologies needed to manage the nation's biological resources.

Variance
A mechanism or provision that allows modification to or waiver of requirements or standards.

Virtual Elimination
A term that refers to the elimination of inputs and discharges of persistent toxic substances with the end goal being their elimination from the Great Lakes Ecosystem. Because it is not practical to completely remove persistent toxic substances, especially from contaminated sediments, the qualifier virtual is appropriate. It may not be possible to achieve total elimination from the Great Lakes System for some persistent toxic substances produced by natural processes and/or by the release of toxins from contaminated sediments. Because of these impediments, virtual elimination is seen by many as a more realistic objective than zero discharge. *See also* Zero Discharge.

Virtual Elimination Pilot Project
A federal project undertaken by the EPA in response to the Great Lakes Water Quality Agreement, that has as its goal the virtual elimination of persistent bioaccumulative chemicals of concern from the Great Lakes basin. Related program: Great Lakes National Program Office.

Virtual Elimination Strategy
A binational report produced by the Virtual Elimination Task Force for the International Joint Commission that outlines a conceptual framework to achieve the virtual elimination of persistent toxic substances from the Great Lakes basin. Related programs: International Joint Commission, Great Lakes Water Quality Agreement.

Virtual Elimination Task Force
A binational organization established by the International Joint Commission to address specific virtual elimination issues in the Great Lakes ecosystem.

Volatile Organic Compounds (VOCs)
Organic chemicals that evaporate readily into the atmosphere, providing a path for transport through the environment.

Voluntary PCB Phasedown Program
A federal program initiated by EPA Region 5 requesting electric utilities in the Great Lakes basin to voluntarily remove from service all electrical equipment containing PCBs at levels greater than 500 parts per million.

Wasteload Allocation (WLA)
The portion of a receiving waters total maximum daily load that is allocated to one of its existing or future point sources of pollution. WLAs constitute a type of water quality-based effluent limitation. Related programs: water-related CFRs and rules, federal and state statues.

Wastewater Treatment Plant (WWTP)
A facility that receives sewage and stormwater from collection structures, then uses various levels of treatment to purify the water. Most modern publicly-owned treatment works in larger municipalities provide primary treatment, secondary treatment, tertiary treatment, and disinfection techniques to kill disease-producing organisms. Related Program: Western Lake Superior Sanitary District.

Water Quality Advisory Board
See Great Lakes Water Quality Advisory Board.

Water Quality Agreement of 1987
A binational agreement that amends the Great Lakes Water Quality Agreement of 1978. Related program: Great Lakes Water Quality Agreement.

Water Quality Board
See Great Lakes Water Quality Advisory Board.

Water Quality Criteria
Numeric or narrative expressions that specify concentrations of water constituents (such as toxic chemicals or heavy metals) which, if not exceeded, are expected to support an ecosystem suitable for protecting life in water and life dependent on water for its existence. States incorporate water quality criteria into their water quality standards to protect public health or welfare, enhance the quality of water, and serve the purposes of the Clean Water Act. Related programs: Clean Water Act, parts of chapter 40 of the CFR.

Water Quality Guidance for the Great Lakes System
The official name for the Great Lakes Initiative. The final version of the guidance was published on March 23, 1995 and has regulatory implications. The guidance establishes minimum water quality standards, anti-degradation policies, and implementation procedures for waters in the

Great Lakes system. Related programs: Great Lakes Toxic Reduction Initiative, Great Lakes Toxic Reduction Effort, Clean Water Act.

Water Quality Standard
A water quality standard defines the water quality goals of a water body, or portion thereof, by designating the use or uses to be made of the water, by setting water quality criteria necessary to protect the uses, and by preventing degradation of water quality through anti-degradation provisions. States adopt water quality standards to protect public health or welfare, enhance the quality of water, and serve the purposes of the Clean Water Act. Related programs: Clean Water Act, parts of chapter 40 of the CFR.

Water Table
The upper surface of the ground water or that level below which the soil is saturated with water.

Water Use Classification
A classification of waters of the state contained in MN Rule Chapter 7050 for the purpose of water quality protection, consideration of the best use in the interest of the public, and other considerations. Water quality standards for each class of waters prescribe the quality of the water that is necessary for the designated uses, as follows: Class 1 waters are for domestic consumption; Class 2 waters for aquatic life and recreation; Class 3 waters for industrial consumption; Class 4 waters for agriculture and wildlife; Class 5 waters for aesthetic enjoyment and navigation; Class 6 waters for other uses; and Class 7 waters for limited resource value waters.

Waters of the State
A term used in Minnesota statutes and regulations that refers to all water bodies regulated by the state. They include streams, lakes, ponds, marshes, watercourses, waterways, wells, springs, reservoirs, aquifers, irrigation systems, drainage systems, and all other bodies or accumulations of water, surface or underground, natural or artificial, public or private, which are contained within, flow through, or border upon the state of Minnesota or any portion thereof.

Waters of the United States
A term used in federal regulations that defines all water bodies regulated as waters of the U.S. It includes: (1) all waters which may be susceptible to use in interstate or foreign commerce; (2) all interstate waters, including interstate wetlands; (3) all other waters, such as intrastate lakes, rivers, streams (including intermittent streams), mud flats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation, or destruction of which could affect interstate or foreign commerce including any such waters; (4) all impoundments of waters otherwise defined as waters of the United States; (5) tributaries of waters identified in this section; (6) the territorial seas; (7) wetlands adjacent to waters (other than waters that are themselves wetlands) identified in this section. Related programs: Clean Water Act, 33 CFRs.

Watershed
The drainage basin or area in which surface water drains toward a lake, stream, or river at a lower elevation. Related programs: Coastal Zone Management Act, Wetland Conservation Act, Clean Water Act.

Western Lake Superior Region Resource Management Cooperative (WLSRRMC)
A multi-agency/university assemblage established to coordinate programs in the Lake Superior basin. It provides coordinated research, information exchange, and outreach and education program support. Its goal is to achieve full benefits of Lake Superior regional waters, air, fish, wildlife, forests, and wildlands and associated resources for their cultural, social, commercial, economic, and recreational utilization and enjoyment. Formed in 1989, the cooperative represents eight federal agencies, Wisconsin and Michigan DNRs, Great Lakes Indian Fish and Wildlife Commission, and six academic instituitions.

Western Lake Superior Sanitary District (WLSSD)
A local agency responsible for sewage treatment, hazardous household and solid waste collection, recycling, and waste disposal for a number of municipalities in the greater Duluth, Minnesota area.

Wet Deposition
The deposition of pollutants from the atmosphere that occurs during precipitation events. Acid rain is one form of wet deposition. Wet deposition is calculated by multiplying precipitation amounts by the pollutant concentration. Wet deposition rates are often very different than dry deposition rates.

Wetland Conservation Act (WCA)
A Minnesota statute that requires regulation for draining and filling activities in wetlands. This act amended various Minnesota statues (namely 103A, 103B, and 103C). Also referred to as Chapter 354.

Wetland Conservation Act Rules (WCAR)
See Minnesota Rule Chapter 8420.

Wetland Mitigation
A regulatory requirement to replace or enhance wetland areas destroyed or impacted by proposed land disturbances with artificially created or restored wetlands.

Wetlands
The lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands must have a predominance of hydric soils and be inundated or saturated by surface water or ground water at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation. This is a legal definition and controversy still exists among scientists and policy makers as to how many of these characteristics must be present in order for an area to be defined as a wetland. Related programs: Wetland Conservation Act, Wetland Conservation Act Rules, Clean Water Act, Section 404.

Whole Effluent Toxicity Test (WET)
The total toxic effect of a complex effluent measured directly by a toxicity test. Related programs: 40 CFR, Great Lakes Initiative.

Wildlife Criteria
Water quality criteria designed to protect wildlife. These are surface water concentrations of toxic substances that will cause no significant reduction in the viability or usefulness (in a

commercial or recreational sense) of a population of animals that use the waters of the Great Lakes system as a drinking and/or foraging source over several generations. Related program: Great Lakes Initiative.

Wisconsin Department of Natural Resources (WI DNR)
A Wisconsin state agency responsible for overall management of the state's natural resources and environmental quality.

Wisconsin Lake Superior Basin Water Quality Management Plan
Wisconsin's five-year blueprint for water quality. This plan, prepared by the WDNR, will be used to set water quality management priorities in the Lake Superior basin.

Zebra Mussel
An exotic species originally introduced into the Great Lakes via the ballast water of transoceanic ships. This small bivalve mussel poses a multibillion dollar threat to industrial, agricultural, and municipal water supplies across North America by clogging water intake pipes. It can also have impacts on fisheries, native freshwater mussels, and natural ecosystems. By moving along contiguous waters of the Great Lakes, attached to ships, barges, and recreational boats, this Eurasian native has rapidly spread throughout the Mississippi River basin and many of its major tributaries, such as the Ohio River. Free-swimming larvae are also spread by river currents. Boater education campaigns focus on preventing further spread of this species.

Zero Discharge
Zero discharge refers to halting all inputs from all human sources and pathways to prevent any opportunity for persistent toxic substances to enter the environment from human activity. To completely prevent such releases, the manufacture, use, transport, and disposal of these substances would have to stop. The Binational Program has designated nine toxic substances (critical pollutants) to be part of the Zero Discharge Demonstration Program for the Lake Superior Basin. These substances are chlordane, dieldrin, dichloro-diphenyl-trichloro-ethane (DDT and its metabolites), hexachlorobenzene (HCB), mercury, octachlorostryrene (OCS), polychlorinated biphenyls (PCBs), 2, 3, 7, 8 tetrachlorodibenzo-p-dioxin (TCDD), and toxaphene.

Zero Discharge Demonstration Program
This international program is in response to the recommendation by the International Joint Commission that Lake Superior be designated a zero discharge demonstration zone where no point source discharge of any persistent bioaccumulative toxic substance be permitted. Nine persistent toxic substances (critical pollutants) have been designated as critical for the program. The first priority of the program is the goal of achieving zero discharge of the nine substances from point sources. To completely prevent such releases, the manufacture, use, transport, and disposal of these substances must stop. This objective is to be met by:

1. pollution prevention;
2. enhanced controls and regulations, and;
3. protection through special designations of all or part of the basin. (*See also* Outstanding International Resource Waters and Outstanding National Resource Waters.)

Related program: Binational Program.

Zone of Initial Dilution (ZID)
The region of initial mixing surrounding or adjacent to the end of an outfall pipe or diffuser. The ZID may not be larger than allowed by mixing zone restrictions in applicable water quality standards.

Zooplankton
Small, mostly microscopic animals that swim or float freely in open water. Zooplankton eat algae, detritus, and other zooplankton and in turn are eaten by fish.

ACRONYMS

AEOLOS	Atmospheric Exchange Over Lakes and Oceans Study
AFRI	Acute febrile respiratory illness
AHA	American Hospital Association
ALC	American Land Conservancy
ANS	Aquatic nuisance species
APHIS	Animal and Plant Health Inspection Service
AOCs	Areas of Concern
A/OFRC	Anishnawbec/Ontario Fisheries Resource Center
AOX	Adsorbable Organic Halides
ATSDR	U.S. Agency for Toxic Substances and Diseases Registry
BIA	Bureau of Indian Affairs
BLS	Bureau of Labor Statistics
BMIC	Bay Mills Indian Community
BMP	Best Management Practice
BOD	Biological oxygen demand
BR	Bad River Band of Lake Superior Chippewa
BRI	Biodiversity Research Institute
BRNRD	Bad River Natural Resources Department
BSC	Bird Studies Canada
BTS	Binational Toxics Strategy
BWCAW	Boundary Water Canoe Area Wilderness
CAA	Clean Air Act (U.S.)
CAMNet	Canadian Atmospheric Mercury Measurement Network
CBG	Census Block Group
CCL	Contaminated Candidates List
CDD	Chlorinated dibenzo-p-dioxins
CEC	North American Commission for Environmental Cooperation
CEPA	Canadian Environmental Protection Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (U.S.)
CFR	Code of Federal Regulations
CFS	Cubic feet per second
CITES	Committee on International Trade in Endangered Species
CLSWP	Central Lake Superior Watershed Partnership
CLSWP	Central Lake Superior Watershed Partnership
COTFMA	Chippewa/Ottawa Treaty Fishery Management Authority

CSD	Census Subdivision
CSO	Combined sewer overflow
CUE	Catch per Unit Effort
CWA	Clean Water Act (U.S.)
CWAP	Clean Water Action Plan
CWS	Canadian Wildlife Service
DAPTF	Declining Amphibian Population Task Force
DDE	1,1-dichloro-2,2-bis (p-chlorophenyl) ethylene
DDT	1,1,1-trichloro-2,2-bis (p-chlorophenyl) ethane
DU	Ducks Unlimited
DWSP	Ontario Ministry of Environment's Drinking Water Surveillance Program
E. coli	Escherichia coli
EA	Enumeration Area
EC	Environment Canada
EPA	United States Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act (U.S.)
EPO	Ecosystem Principles and Objectives for Lake Superior
ESRI	Environmental Systems Research Institute
FAQs	Frequently Asked Questions
FDL	Fond du Lac Band of Lake Superior Chippewa
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act (U.S.)
FON	Federation of Ontario Naturalists
FSL	Forest Science Laboratory
FT	Feet
FWCA	Fish and Wildlife Conservation Act
FWS	United States Fish and Wildlife Service
g	Grams
GI	Gastro-intestinal
GIS	Geographical Information Systems
GLBTDP	Great Lakes Ballast Water Technology Demonstration Project
GLC	Great Lakes Commission
GLERL	Great Lakes Environmental Research Laboratory
GLFC	Great Lakes Fishery Commission
GLFT	Great Lakes Fishery Trust
GLI	Great Lake Initiative
GLIFWC	Great Lakes Indian Fish and Wildlife Commission
GLNPO	Great Lakes National Program Office

GLWQA	Great Lakes Water Quality Agreement
GLSC	Great Lakes Science Center
GP	Grand Portage Band of Lake Superior Chippewa
Ha	Hectare
HCB	Hexachlorobenzene
Hg	Mercury
HYSPLIT	Hybrid Single Particle Langrangian Integrated Trajectory
IADN	Integrated Atmospheric Deposition Network
IJC	International Joint Commission (IJC)
ITFAP	Inter-Tribal Fisheries and Assessment Program
KBIC	Keweenaw Bay Indian Community
km	Kilometer
L	Liter
LaMP	Lakewide Management Plan
LCO	Lac Courte Oreilles
LPBO	Long Point Bird Observatory
LNFAU	Lake Nipigon Fisheries Assessment Unit
LSB	Lake Superior basin
LSBP	Lake Superior Binational Program
LSC	Lake Superior Chippewa
LSHC	Habitat Committee of the Lake Superior Binational Program
LSSU	Lake Superior State University
LVD Tribe	Lac Vieux Desert Tribe
m	Meters
MAC	Maximum Acceptable Concentration
MACT	Maximum Available Control Technology
MAS	Michigan Audubon Society
MCL	Maximum Contaminant Level
MCR	Midcontinent rift
MCRBMA	Mercury-Containing and Rechargeable Battery Management Act of 1996
MDEQ	Michigan Department of Environmental Quality
MDN	Mercury Deposition Network
ME	Maine
MEI	Morphoedaphic Index
MI	Michigan
MI DNR	Michigan Department of Natural Resources
MI LPA	Michigan Loon Preservation Association

MI NFI	Michigan Natural Features Inventory
MINGF	Michigan Non Game Fund
MITA	Michigan Trappers Association
MN	Minnesota
MN DNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
MSU	Michigan State University
MTU	Michigan Technological University
MVEC	Mean vertical extinction coefficients
NABS	National Ballast Survey
NAFEC	North American Fund for Environmental Cooperation
NAFTA	North American Free Trade Agreement
NANPCA	Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990
NATA	National Air Toxics Assessment
NCES	Northcentral Experiment Station
NGO	Non Government Organization
NHIC	Natural Heritage Information Center
NISA	National Invasive Species Act
NL	National Lakeshore
NMU	Northern Michigan University
NOAA	National Oceanic and Atmospheric Administration
NOBOB	“no ballast on board”
NP	National Park
NPDES	National Pollutant Discharge Elimination System
NPDWR	National Primary Drinking Water Regulations
NPS	National Park Service
NRCS	Natural Resource Conservation Service
NRRI	Natural Resources Research Institute
NWF	National Wildlife Federation
NWI	National Wetland Inventory
NWR	National Wildlife Refuge
NYSDEC	New York State Department of Environmental Conservation
OAR	Office of Air and Radiation
OCS	Octachlorostyrene
OFMF	Ontario Fur Managers Federation
OFO	Ontario Field Ornithologists
OGWDW	Office of Groundwater and Drinking Water

OIA	Ottawa Interpretive Association
OIRW	Outstanding International Resource Water
OME	Ontario Ministry of the Environment (OME)
OMEE	Ontario Ministry of Environment and Energy
OMNR	Ontario Ministry of Natural Resources
OMOE	Ontario Ministry of Environment
ON	Ontario
ONRW	Outstanding National Resource Waters
ORD	Office of Research and Development
OST	Office of Science and Technology
OTA	Office of Technology Assessment
OW	Office of Water
P2	Pollution Prevention
PAHs	Polycyclic Aromatic Hydrocarbons
PBT	Persistent bioaccumulative toxic
PCBs	Polychlorinated biphenyls
PCP	Pentachlorophenol
PEAC	Pacific Environmental Advocacy Center
POM	Polycyclic organic matter
POP	Persistent organic pollutants
POTW	Publicly Owned Treatment Works (wastewater treatment)
RAPs	Remedial Action Plans
RC	Red Cliff Band of Lake Superior Chippewa
RCFD	Red Cliff Fisheries Department
RCRA	Resource Conservation and Recovery Act (U.S.)
RD	Ranger District
REMAP	Regional Environmental Monitoring and Assessment Project
RETAP	Retired Engineer Training and Assistance Program
RGS	Ruffed Grouse Society
SARA	Superfund Amendments and Reauthorization Act (U.S.)
SERC	Smithsonian Environmental Research Center
SGNIS	Sea Grant Nonindigenous Species Site
SLC	Sea Lamprey Control
SOEI	Sigurd Olson Environmental Institute
SOLEC	State of the Lakes Ecosystem Conference
SSO	Sanitary Sewer Overflow
SWPP	Source Water Protection Program

TCBO	Thunder Cape Bird Observatory
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TCDF	2,3,7,8-tetrachlorodibenzofurans
TEA	Toronto Entomologists Association
TEQ	Toxic equivalence quotient
THMs	Trihalomethanes
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
TOC	Total Organic Carbon
TSCA	Toxic Substances Control Act (U.S.)
TU	Trout Unlimited
TWCC	Terrestrial Wildlife Community Committee
U of MN	University of Minnesota
UNDERC	University of Notre Dame Environmental Research Center
UP	Upper Peninsula
UPPCO	Upper Peninsula Power Company
UPRCD	Upper Peninsula Recreation, Conservation and Development
U.S.	United States
USCG	United States Coast Guard
USDA	United States Department of Agriculture
U.S. EPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USGS-BRD	United States Geological Survey - Biological Resources Division
UV-B	Ultraviolet Radiation
UWSP	University of Wisconsin Stevens Point
VMS	Volcanogenic massive sulphide
WI	Wisconsin
WI DNR	Wisconsin Department of Natural Resources
WL	Wildlife
WLSSD	Western Lake Superior Sanitary District
WPBO	Whitefish Point Bird Observatory
WPS	White Pine Society

Lake Superior LaMP 2000 *errata*

Chapter 1 Introduction

Replace the first two paragraphs of section 1.1.2 Ecosystem Components with the following:

“ Ecosystem Components

While initial focus of LaMP work was on reduction of critical pollutants, establishing the Zero Discharge Demonstration Project, and the Broader Program that advanced understanding of habitat and landscapes, work has recently begun in other areas. Partner agencies have developed Lakewide Management Plans for five additional ecosystem themes: aquatic communities, terrestrial wildlife communities, habitat, human health and developing sustainability. Work in these areas is released now for the first time for public comment and review in the *Lakewide Management Plan 2000*.

Adopting an ecosystem approach has begun a shift from a narrow perspective of managing environmental components like water, air and soil, or a single resource such as fish and trees, to a broader perspective that focuses on managing human uses and abuses of entire watersheds. This approach comprehensively addresses all aspects of the environment and resources within the context of a living system. The vision statement of the Lake Superior Binational Forum recognizes environmental integrity as the foundation for a healthy economy, that development of wild shorelines be conducted in an environmentally benign manner, and that citizens accept responsibility for their lifestyles. Guided by this vision, agencies developed the *Ecosystem Principles and Objectives* document for the Lake Superior ecosystem. Committees of the Superior Workgroup continue to refine objectives and indicators for six theme areas. Below are the current objectives:”

Chapter 5 Human Health

Insert the following references:

Whitman, R.L., Gochee, Angel V., Dustman, Wendy A., Kennedy, Kevin J., 1995. Use of coliform bacteria in assessing human sewage contamination. *Natural Areas Journal. 15:227-233*.

World Health Organization, 1998. Guidelines for safe recreational-water environments: coastal and fresh-waters.

World Health Organization, 1984. Definition of Health. Geneva.

Pruss, A (1998) Review of epidemiological studies on health effects from exposure to recreational water. *International Journal of Epidemiology. 27 (1): 1-9.*

Chapter 8 Aquatic Communities

Executive Summary 3rd paragraph: insert "in Areas of Concern" *following "….industrial effluents".*

Section 8.1.1 Lake Superior Resources and their Stressors,

page 8-11:
"Principal stresses in aquatic habitat", 5th bullet, insert " in Areas of Concern" *following "… industrial effluents".*
Page 8-12: "The principal stresses found in each habitat type…"
Nearshore: insert "in Areas of Concern" *following "…industrial effluents".*
Embayment: insert "in Areas of Concern" *following "…industrial effluents".*
Tributary: insert "in Areas of Concern" *following "…industrial effluents".*
Inland Lakes: insert "in Areas of Concern" *following "…industrial effluents".*

Section 8.1.2 Inland Lake Aquatic Resources and their Stresses,
Michigan section, 3rd paragraph,
replace: " Michigan Department of Environmental Quality" *with* "Michigan Department of Community Health".

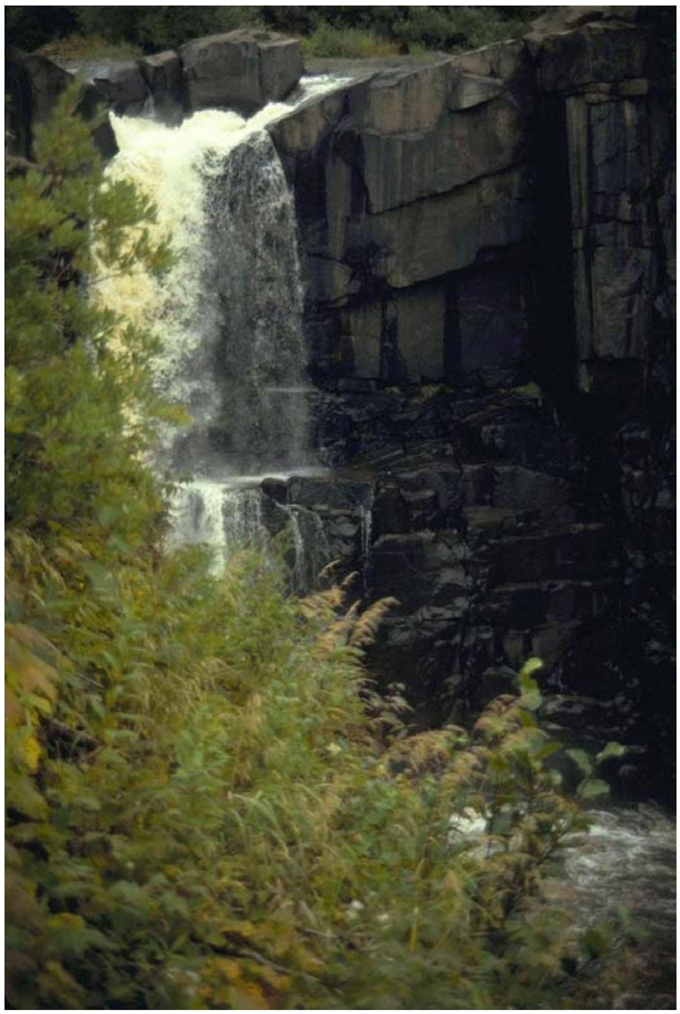
AOC Name	Primary Contaminants	Geographic Area	Stressors	Beneficial Use Impairments	Funding Programs and Partners	Clean-Up Actions Completed	Key Activity Needed	Barriers	Next Steps
St Marys River **Michigan/ Ontario**	▪ PAHs ▪ Arsenic ▪ Cyanide ▪ Phosphorus ▪ Benzene ▪ Toluene ▪ Oil and grease ▪ Phenols ▪ Ammonia ▪ Pathogens/ Bacteria	From the head of the river at Whitefish Bay (Point Iroquois - Gros Cap), downstream through the St. Joseph Channel to Humburg Point on the Ontario side, and to the straits of Detour on the Michigan side.	▪ Combined sewer overflows ▪ Loss of wetlands ▪ Point and nonpoint source pollution ▪ Wastewater discharges ▪ Urban/industrial development ▪ Navigational structures	▪ Fish and wildlife consumption restrictions ▪ Fish and wildlife degradation ▪ Fish tumors or other deformities ▪ Degradation of benthos ▪ Dredging activities restrictions ▪ Eutrophication or undesirable algae ▪ Beach closings ▪ Aesthetics degradation ▪ Loss of fish and wildlife habitat	▪ Superfund ▪ Clean Water Act ▪ Navigational dredging ▪ Canada Ontario infrastructure program ▪ Great Lakes Sustainability Fund ▪ Canada-Ontario Agreement funds (provincial)	▪ Superfund site restored ▪ Combined sewer separation for Sault Ste. Marie, MI. ▪ Steel and paper mills in Sault Ste. Marie, ON improved quality of effluent ▪ Environmental Management Agreement among Algoma Steel, Canada and Ontario ▪ Infrastructure upgrades by Sault Ste. Marie, Ontario	▪ Complete contaminated sediment assessment ▪ Upgrade East End STP to secondary treatment (underway)		▪ Superfund monitoring at cleaned site. ▪ Development and implementation of sediment management program
Deer Lake **Michigan**	• Mercury • Historic Nutrient Loadings	A 906-acre impoundment in central Marquette County, Michigan that includes the Carp River watershed, comprised of Carp Creek, Deer Lake, and the Carp River downstream 20 miles to Lake Superior at Marquette.	▪ Contaminated sediments from waste materials associated with historic iron, gold and silver mining practices	▪ Fish and wildlife consumption restrictions ▪ Dredging activities restrictions	▪ Contaminated sediments	▪ Sewer separation and primary treatment plants secondary wastewater treatment ▪ Deer Lake was drawn down and refilled to allow methylation of mercury from exposed sediments	▪ Dredging ▪ Identify and restore beneficial uses of the Carp River watershed	▪ Lack of dedicated resources ▪ PRP and state negotiations have not been completed	▪ Sediment remediation ▪ Complete analysis of beneficial use impairments
Torch Lake **Michigan**	• Copper • Mercury • Arsenic • Lead • Chromium • Heavy metals	The lower portion of the Keweenaw Peninsula, (368 sq. miles), encompassing the Keweenaw Waterway, (North Entry Harbor of Refuge, Portage Lake, and Torch Lake), its watershed, portions of 2 other adjacent watersheds (Trout R. and the Eagle R. Complex), and several miles of its western Lake Superior shoreline	▪ Contaminated sediments from mine tailings associated with historic copper mining and milling practices ▪ Upland mine tailings deposits from historic copper mining activities which have been deposited into area lakes and streams	▪ Fish and wildlife consumption restrictions ▪ Degradation of benthos ▪ Dredging activities restrictions ▪ Drinking water consump. restrictions, or taste or odor ▪ Aesthetics degradation ▪ Loss of fish and wildlife habitat	▪ Superfund ▪ MDEQ Superfund, AOC and District	▪ 97% of the Superfund - recommended remedial actions have completed – coverage of exposed mine tailings and stamp sands ▪ Completion of ▪ Final Suprfund remedial actions expected 2005	▪ Completion of Superfund-recommended remedy	▪ Requires $15.2M dedicated to Superfund remedial activities from Federal and State funds	▪ Completion of Superfund site remediation ▪ Completion of Superfundsite delisting discussions and delisting ▪ Begin BUI/AOC delisting discussions and recommendations

AOC Name	Primary Contaminants	Geographic Area	Stressors	Beneficial Use Impairments	Funding Programs and Partners	Clean-Up Actions Completed	Key Activity Needed	Barriers	Next Steps
St. Louis River **Minnesota/ Wisconsin**	▪ PAHs ▪ Mercury ▪ Suspended sediment ▪ PCBs ▪ Other metals ▪ Oil and grease ▪ Pathogens ▪ Nutrients	St. Louis Bay, the Nemadji River basin and the St. Louis River basin to Cloquet, Minnesota	▪ Contaminated sediments ▪ Abandoned hazardous waste sites ▪ Poorly designed or leaky landfills ▪ Industrial discharges and chemical spills ▪ Infiltration and inflow ▪ Point and nonpoint sources ▪ Sewage overflows and leaking septic systems ▪ Municipal and industrial runoff ▪ Turbidity ▪ Sedimentation	▪ Fish and wildlife consumption restrictions ▪ Fish and wildlife degradation ▪ Fish tumors or other deformities ▪ Degradation of benthos ▪ Dredging activities restrictions ▪ Excess loadings of nutrients and sediment to Lake Superior ▪ Beach closings ▪ Aesthetics degradation ▪ Loss of fish and wildlife habitat	▪ Superfund ▪ Navigational dredging ▪ GLNPO ▪ States	▪ Wastewater treatment ▪ Sediment contamination studies to identify hotspots ▪ Evaluation of cleanup options at two Superfund sites ▪ Prioritization of remaining hotspots per the Stage 2 Sediment Assessment Strategy ▪ Habitat Management Plan ▪ Key habitat area acquisition ▪ Newton Creek Cleanup	▪ Assessment of fish and wildlife health (body burden and health implications) ▪ Assessment of nonpoint sources of pollution to AOC ▪ AOC specific wetlands protection and restoration program ▪ Selective clean up of contaminated sediments ▪ Cost-benefit analyses of clean up and habitat restoration alternatives ▪ Control of vessel discharges (ballast and bilge water) ▪ Updating of RAP documents	▪Lack of dedicated resources ▪Lack of funding source to manage sediment contamination on an AOC-wide, bi-state basis ▪Lack of financial support from the federal government ▪Lack of cost estimates for protection, restoration, or clean up activities ▪Lack of long term horizon - policies and funding ▪Organizations and budgets focused on short term ▪Difficulty in maintaining public long term support	▪ Contaminated site remediation ▪ Mercury reduction ▪ Habitat restoration and protection ▪ Stormwater and infiltration and inflow control ▪ Update AOC-wide contaminated sediment strategy
Thunder Bay **Ontario**	▪ Pathogens ▪ Mercury ▪ PAHs	About 28 km along the shoreline and up to 9 km offshore, including the watershed	▪ Contaminated sediments ▪ Agricultural runoff ▪ Industrial and municipal effluent ▪ Industrial development	▪ Fish and wildlife consumption restrictions ▪ Fish and wildlife degradation ▪ Degradation of benthos ▪ Dredging activities restrictions ▪ Beach closings ▪ Aesthetics degradation ▪ Phytoplankton and zooplankton pops. Degradation ▪ Loss of fish and wildlife	▪ Great Lakes Sustainability Fund ▪ Canada Ontario Infrastructure Programs ▪ Canada-Ontario Agreement funds (provincial) ▪ Abitibi Consolidated ▪ Northern Wood Preservers ▪ Canadian National	▪ Secondary treatment installed for a number of pulp and paper mills ▪ Clean up and rehabilitation of contaminated Northern Wood site ▪ Various habitat creation and enhancement projects ▪ Chippewa Beach	▪ Upgrade STP to secondary treatment (underway) ▪ Nonpoint pollution		Complete sediment assessment at north end of harbour

AOC Name	Primary Contaminants	Geographic Area	Stressors	Beneficial Use Impairments	Funding Programs and Partners	Clean-Up Actions Completed	Key Activity Needed	Barriers	Next Steps
				habitat	Railway	restoration			
Nipigon Bay **Ontario**	▪ Solids ▪ Pathogens ▪ Biological Oxygen Demand (BOD)	A large portion of Nipigon Bay and the Nipigon River downstream of Alexander Dam. Two communities are located in the vicinity of the Bay: Red Rock (population: 1,300) and Nipigon (population: 1,900).	▪ Water level and flow fluctuations ▪ Wastewater discharges ▪ Nonpoint source pollution	▪ Fish and wildlife degradation ▪ Degradation of benthos ▪ Eutrophication or undesirable algae ▪ Aesthetics degradation ▪ Loss of fish and wildlife habitat	▪ Great Lakes Sustainability Fund ▪ Canada Ontario Infrastructure Programs ▪ Canada-Ontario Agreement funds (provincial)	▪ Created water management plan for Nipigon River to regulate hydroelectric facilities' water use to help restore brook trout ▪ Various habitat restoration projects ▪ Secondary treatment installed at Norampac	▪ Upgrade primary STPs in Redrock and Nipigon	▪ Lack of dedicated resources	▪ Work toward STP upgrades
Jackfish Bay **Ontario**	▪ Solids (i.e. wood fiber) ▪ AOX ▪ dioxin	The 14 km reach of Blackbird Creek between Kimberly-Clark Canada Inc. pulp mill and Jackfish Bay, including Lake A, Moberly Lake and Jackfish Bay itself.	▪ Industrial discharge ▪ Spills ▪ Contaminated sediments	▪ Fish and wildlife consumption restrictions ▪ Fish and wildlife degradation ▪ Fish tumors or other deformities ▪ Bird or animal deformities or reproductive problems ▪ Aesthetics degradation ▪ Loss of fish and wildlife habitat	▪ Great Lakes Sustainability Fund ▪ Canada-Ontario Agreement funds (provincial) ▪ National Sciences and Engineering Research Council of Canada (NSERC)	▪ Effluent quality from paper mill improved ▪ Chlorine dioxide bleaching plant upgraded resulting in lower AOX levels (not 100% of time)	▪ Eliminate mill discharge from ecosystem cycling ▪ Update sediment monitoring data	▪ Natural recovery takes time ▪ Available technology needs to be utilized at all times	▪ Continued natural recovery and monitoring ▪ establish cause of effluent impact on fish
Peninsula Harbour **Ontario**	▪ Mercury	Peninsula Harbour proper, and a portion of open Lake Superior immediately south of the peninsula.	▪ Contaminated sediments	▪ Fish and wildlife consumption restrictions ▪ Fish and wildlife degradation ▪ Degradation of benthos ▪ Dredging activities restrictions ▪ Loss of fish and wildlife habitat	▪ Great Lakes Sustainability Fund ▪ Canada-Ontario Agreement funds (provincial) ▪ Town of Marathon ▪ Federal Economic Development Initiative for northern Ontario (FEDNOR) ▪ Great Lakes Renewal Foundation	▪ Pulp kraft mill installed secondary treatment for effluent, discharge moved out of harbour	▪ Complete contaminated sediment assessment		▪ Complete feasibility study

Appendix B

Total Maximum Daily Load (TMDL) Development Strategy for Lake Superior



Pigeon River High Falls, MN-ON Border
Photograph by: Minnesota Sea Grant

Lake Superior Lakewide Management Plan
2000

Appendix B
Total Maximum Daily Load (TMDL) Development Strategy for Lake Superior

1.0 Introduction

This strategy planning document identifies the goals, objectives, processes, and key issues related to the development and use of Total Maximum Daily Loads (TMDL) for the open waters of Lake Superior. The procedures outlined in this document are consistent with those stipulated under the Water Quality Guidance for the Great Lakes System (40 CFR Part 132, Appendix F) and other U.S. Environmental Protection Agency (U.S. EPA) regulations, policy, and guidance promulgated or published under the authority of Section 303 of the Clean Water Act (CWA).

TMDLs for tributaries to Lake Superior are being addressed by the states. Nonetheless, TMDL activities relating to those tributaries are included in this document because of their importance to the quality of the open waters of the lake.

This document is intended to generate discussion and will guide the development of the final TMDL Strategy for Lake Superior. The strategy will map out a plan to coordinate the work of U.S. EPA, the states, and other interested stakeholders involved in the TMDL process. The strategy will not discuss TMDL implementation; that will be part of any TMDL that is ultimately developed. Furthermore, since a TMDL is only one of many tools discussed below for managing the Great Lakes, other protection and restoration efforts will not wait for the development of a TMDL and may eventually make a TMDL for the open waters of the lake unnecessary. As a result, this document is only the first step in a lengthy process.

This strategy planning document is organized in six sections and one appendix. Following this introduction, Section 2.0 provides background on the status of Lake Superior and 303(d) listed water segments within the Lake Superior watershed. Section 3.0 describes the TMDL process and compares it with the Lakewide Management Program (LaMP) program goals defined under the Great Lakes Water Quality Agreement (GLWQA). Section 4.0 describes the key issues to be resolved to develop a Lake Superior TMDL Strategy. Section 5.0 presents a framework for a TMDL strategy to serve as a "strawman" for generating discussion and comment. Section 6.0 briefly describes the next steps in the TMDL strategy development process. Finally, Appendix A lays out the key steps in the TMDL process.

General Relationship Among a TMDL Strategy and Other Management Programs and Tools

The TMDL Strategy will address one of many tools that can be used to manage Great Lakes ecosystem quality. The following discussion generally outlines the statutory basis for water quality management and the variety of tools for addressing water quality impairment in the lakes.

The Lake Superior LaMP describes those programs and activities in greater detail. This introductory discussion is intended to place the TMDL program within the larger context of Great Lakes management.

Statutory Authorities: Setting Goals

The CWA provides the overall goals (fishable, swimmable, and drinkable) and authority for regulating certain activities that affect clean water in this country. In addition, the GLWQA between the United States and Canada defines more specific and common goals for the Great Lakes basin. The states and tribes use provisions of the CWA for designating water body uses and the necessary standards to be met to support those uses. Any request for a National Pollutant Discharge Elimination System permit (NPDES) to discharge into a water body is judged against the designated use for the receiving water body and the adopted state standards. Within the Great Lakes Basin, those water quality standards must meet the Great Lakes Water Quality Guidance objectives, including: 1) being no less restrictive than the limits on pollutants that protect human health, aquatic life and wildlife; 2) encompassing anti-degradation policies; and 3) incorporating implementation procedures.

Tools: Regulatory, Non-regulatory, and Voluntary Approaches for Pollution Control

Under the statutory authorities governing lake water quality management, a variety of regulatory and non-regulatory programs are implemented at the federal, state, and local levels. In addition, the public and private sectors implement voluntary pollution reduction programs and strategies to reduce pollutant load to the lakes. Several of these programs are described below.

Water Discharge Permitting. The CWA prohibits discharges of "pollutants" through a "point source" into a "water of the United States" unless the discharge is authorized under a NPDES permit. The permit specifies limits on effluent concentrations and loads, monitoring and reporting requirements, and other provisions to ensure that the discharge does not impair water quality or human health. In essence, the permit translates general CWA requirements into specific provisions tailored to the operations of each entity discharging pollutants. Michigan, Minnesota, and Wisconsin all have been delegated their NPDES permit programs and are authorized to issue permits.

TMDL - Achieving Water Quality Standards. For those waters not meeting quality standards after application of wastewater treatment technology mandated through an NPDES permit, states are required to calculate a TMDL. TMDL calculations are usually complex and may address a variety of pollutant sources. Although the States have primary responsibility for performing TMDLs, U.S. EPA will provide resources for technical assistance to assist in developing TMDLs, including TMDLs for interstate waters like the Great Lakes.

Technical and Economic Assistance. Pollutant load reductions to the Great Lakes are also supported through technical and economic assistance provided by the basin governments. For example, Section 319 of the CWA authorizes U.S. EPA to provide funds to the States for nonpoint source control project grants. Similarly, the U.S. Department of Agriculture provides economic assistance through the Environmental Quality Incentives Program to aid in controlling agricultural runoff. Overall, scores of federal, state, local, and private assistance programs are available to help reduce pollutants and control pollutant load to the lakes.

Pollution Prevention Partnerships. Partnerships among governments, the private sector, and other interested stakeholders help achieve voluntary pollution reductions. For example, through Partners for the Environment, EPA collaborates with more than 7,000 organizations that use voluntary goals and commitments to achieve measurable environmental results in a timely and cost-effective way. Partners include small and large businesses, citizens groups, state and local governments, universities and trade associations.

The results of voluntary actions taken through more than 20 distinct partnership programs are impressive. Focusing on pollution prevention, organizations set and reach environmental goals such as conserving water and energy or reducing greenhouse gases, toxic emissions, solid wastes, indoor air pollution and pesticide risk.

Tools: Assessing Watershed Conditions

In addition to placing controls on pollutant load to the lake, new programs are in place to improve the long-term assessment of water quality conditions in the basin. The 1998 Clean Water Action Plan (CWAP) began the process of developing *unified watershed assessments* based on the consolidation of information for a whole *watershed* from multiple federal, state, tribal and intergovernmental groups assessment tools. These assessments build upon the data collection, assessment, and reporting activities mandated under Sections 305(b), 303(d), and 304(l) of the CWA. The plan identifies unified watershed Categories I through IV . The categories are: I) not meeting clean water and other natural resources goals, II) prevention action is needed to sustain water quality and aquatic resources, III) outstanding resource waters deserving of the highest protection and IV) watersheds with insufficient data.

Tools: Restoring Degraded Portions of the Lake Superior Ecosystem

Finally, restoration activities administered by the federal government and the states are also an integral part of Great Lakes management. In particular, CERCLA has provided authority and funding to support sediment and other remediation in the Areas of Concern and other degraded areas within the basin. The CWAP calls for states and tribes, working with all appropriate agencies, organizations and the public to identify the Category I watersheds most in need of restoration beginning in the 1999-2000 period. A schedule will be developed and coordinated with the list of waters that do not meet adopted State Water Quality Standards under section

303(d) of the CWA.

Coordinating Lake Management Activities through Planning

The CWAP and the Lake Superior LaMP both call for working with the numerous federal agencies, states, tribes and other organizations to address the impairments. For the portions of Lake Superior requiring a TMDL, a convening and coordinating committee will be identified to address the Lake Superior issues. The time frame for filling the data gaps and the resources available will help determine the TMDL strategy and schedule for Lake Superior. The following discussion provides a starting point for the TMDL Strategy development process.

2.0 Background - Status of Lake Superior and State TMDL Programs

Lake Superior supports many beneficial uses, including recreation, drinking water supply, ecological habitat, and certain industrial and commercial uses. Nonetheless, despite overall reductions in conventional and toxic pollutant loads to Lake Superior over the past 20 years, data indicate that pollutants still exert negative impacts on the chemical, physical, and biological components of the Lake Superior ecosystem. The remaining problems in Lake Superior are significantly related to legacy contamination. Specifically, the lake ecosystem contains contaminants at levels that result in fish consumption advisories, impairments to aquatic organisms and wildlife, impacts on dredging, eutrophication, and contamination of drinking water sources.

Fish consumption advisories are generally the result of elevated PCB, mercury, dioxin-like furans, chlordane, DDE, dieldrin, and toxaphene levels in fish tissue. These advisories also exist in many of the Lake Superior tributaries.

Other pollutants cause or contribute to use impairment on a local or regional scale in Lake Superior. The Stage 1 LaMP identified critical pollutants and pollutant groups present at harmful levels in the ecosystem that require reductions at the source or removal from the ecosystem to restore beneficial uses or to achieve ecosystem objectives or environmental quality criteria. The Lake Superior critical pollutants include the following that are targeted for zero discharge:

- Chlordane
- DDT and metabolites
- Dieldrin/aldrin
- Hexachlorobenzene
- Octachlorostyrene
- PCBs
- 2,3,7,8-TCDD
- Toxaphene
- Mercury

The Lake Superior critical pollutants also include the following critical pollutants that are not targeted for zero discharge and emissions but impair beneficial uses, exceed environmental criteria, and/or do not meet ecosystem objectives:

- Alpha-BHC
- Heptachlor epoxide
- PAHs
- Aluminum
- Arsenic
- Cadmium
- Chromium
- Copper
- Iron
- Lead
- Manganese
- Nickel
- TCDD (TEQ) dioxins and furans
- Zinc

Some pollutant loadings are of concern in Lake Superior and have properties (bioaccumulative, persistent, and toxic) that give them the potential to impair the lake. These chemicals have been found below water quality standards or have not been monitored in Lake Superior. The Stage 1 LaMP identified these pollutants as prevention pollutants. The Stage 2 LaMP proposed a list of prevention pollutants. These prevention pollutants include:

- 2-chloroaniline (4,4-methylenebis)
- 1,4- dichlorobenzene
- 3,3'-dichlorobenzidine
- Hexachlorobutadiene
- beta-BHC
- delta-BHC
- gamma-BHC (Lindane)
- Mirex
- Pentachlorobenzene
- Pentachlorophenol
- Photomirex
- 1,2,3,4-tetrachlorobenzene
- 1,2,4,5-tetrachlorobenzene
- Tributyl tin

303(d) Listed Water Segments

Lake Superior and many of its tributaries are impaired due to fish consumption advisories for mercury and PCBs and do not meet water quality standards for other constituents. Waters that do not meet water quality standards require a state-developed TMDL for each water body and pollutant. There are no lists for degraded waterbodies in Ontario, nor are there timetables for improving such waters. Table 1 lists the impaired water bodies, both Lake Superior segments and U.S. tributaries discharging directly into Lake Superior, the parameters of concern resulting in the State's identification of the impaired or threatened water body under Section 303(d) of the Clean Water Act, and the schedule for completing the TMDL for the water body. Table 1 includes those listed water bodies discharging to Lake Superior.

Table 1. Lake Superior State 303(d) List Summaries

State	Water Body	Schedule	Parameters of Concern								
			WQS-PCBs	WQS-Mercury	FCA-PCBs	FCA-Mercury	E. Coli	Lead	Pesticides	D.O.	Other
MN	Beaver River	1999-2010, 2007-2010		✓							Turbidity
	Brule River	1999-2010		✓							
	Knife River	1999-2010, 2001-2004		✓							Turbidity
	Lester River	1999-2010, 2004-2007		✓							Turbidity
	Poplar River	1999-2010		✓							
	St. Louis Bay	1999-2010		✓							
	St. Louis River	1999-2010		✓							
	Talmadge River	2005-2010								✓	
MI	Carp Creek and River	2003				✓					
	Eagle River, East and West branches	2008									Poor macroinvertebrate, WQS-copper
	Mineral River	2003									Poor macroinvertebrate, WQS-TDS
	Lake Superior										FCA
WI	Allouez Bay				✓	✓					FCA
	Crawford Creek										PAH, petroleum, aquatic toxicity
	Hog Island inlet										PAH, petroleum
	St. Louis Bay				✓	✓					
	St. Louis River				✓	✓					
	Superior Bay				✓	✓					

Notes:

CSO = Combined sewer overflows; D.O. = Dissolved oxygen; FCA = Fish consumption advisory; WQS = Water quality standard

Water Quality Standards Applicable to Lake Superior

Under the Water Quality Guidance for the Great Lakes System, the Great Lakes states and tribes are to adopt numeric water quality criteria and water quality programs that are consistent with 40 CFR Part 132. As a result, once approved by U.S. EPA, water quality standards (WQS) for constituents identified under 40 CFR 132.3 promulgated by the states and tribes for waters in the Lake Superior system will be consistent with the minimum requirements of 40 CFR Part 132. Water quality standards currently promulgated by the states are found at the following:

Minnesota

Minnesota Rules (MR) Chapter 7050.0200 groups surface waters in to one or more usage classes:

- Class 1: Domestic consumption waters
- Class 2: Aquatic life and recreation waters
- Class 3: Industrial consumption waters
- Class 4: Agriculture and wildlife waters
- Class 5: Aesthetic enjoyment
- Class 6: Other uses
- Class 7: Limited resource value waters

MR Chapter 7050.0470 subpart 1 identifies the water use classifications for specific waters in the Lake Superior basin. General WQS applicable to the waters in the Lake Superior basin are found in MR Chapters 7050 and 7065. Minnesota sets WQS specific to for class 2A, 2Bd, 2B, 2C, and 2D waters in the Lake Superior Basin in MR Chapter 7052 for the Great Lakes Initiative pollutants.

Michigan

The State of Michigan sets WQS and methods for calculating standards and criteria for the Great Lakes, the connecting waters, and all other surface waters of the state under Part 4 of the Natural Resources and Environmental Protection Act, Act 451 of 1994.

Wisconsin

The State of Wisconsin sets WQSs and methods for calculating standards and criteria for Wisconsin surface waters under the Wisconsin Administrative Code (WAC) Chapter Natural Resources (NR) 102. WAC Chapter NR 104 sets uses and designated standards for intrastate and interstate waters and WAC Chapter NR 105 sets surface water quality criteria and secondary values for toxic substances. All surface waters within the drainage basin of the Great Lakes are to be protected from the impacts of persistent, bioaccumulating toxic substances by avoiding or limiting to the maximum extent practicable increases in those substances.

3.0 The Relationship Between the TMDL and LaMP Processes

This section first describes the key elements that a Lake Superior TMDL strategy would need to address. The section then provides an overview of the 12 key components or steps in TMDL development. The section concludes with a comparison of the TMDL and LaMP processes.

Key Elements of a TMDL Strategy

Any TMDL strategy developed for Lake Superior should focus on five key elements: 1) Goals and Objectives, 2) Scope and Scale, 3) Monitoring and Data, 4) Coordinated Planning Efforts, and 5) Partnerships.

GOALS AND OBJECTIVES: If the TMDL process is to be successful, sound and achievable goals and objectives must be identified. Several statutory and planning processes have established goals and objectives, along with specific substances identified as critical pollutants that need to be controlled or eliminated. Strategically, it will be important to evaluate all of the associated goals and objectives under the various planning processes to ensure that there are no conflicts. It is also important to evaluate all of the substances identified as pollutants to determine which ones can or should be readily controlled through a TMDL process, and which ones will need to be managed though some other process. As part of a strategic planning process, it will be important to narrow down the goals and objectives, as well as the substances identified as critical pollutants into a clear and concise suite that meets the guidelines for waterbodies or waterbody segments needing TMDLs. The TMDL process is just one of many tools used to address specific goals and objectives and certain critical pollutants that are currently causing an impairment to meeting the designated uses of the Great Lakes and their basins. The development of TMDLs does not preclude the use of other mechanisms to attain the other goals and objectives that have been set forth for the Great Lakes and their basins by the various planning and statutory processes.

Those statutory and planning processes that have identified goals and objectives along with identified critical pollutants include:

1) The designated uses of the waterbody or waterbody segment, as established by the states along with the applicable water quality standards and criteria associated with the identified designated uses (which are to be consistent with the Water Quality Guidance for the Great Lakes System, 40 CFR Part 132).

2) The Great Lakes Initiative which established final water quality guidance for the Great Lakes Systems for criteria limits or methodologies for the control of bioaccumulative chemicals of concern (BCCs), USEPA, March 1995.

3) The Great Lakes Water Quality Agreement which identifies both the 14 beneficial uses for the Great Lakes and the requirement for no increase in toxic loads, 1972, and the amendments of 1978 and 1987.

4) The Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem (COA), 1994, which identifies specific substances to be controlled.

5) The International Joint Commission (IJC), 1987, which identified substances as critical pollutants.

6) The Great Lakes Binational Toxics Strategy, which focuses on the virtual elimination of persistent toxic substances in the Great Lakes.

7) The Area of Concerns and their corresponding Remedial Action Plans (RAPs) which have identified goals and objectives.

8) The goals and objectives identified in the LaMPs, along with the substances designated as lakewide critical pollutants.

9) The goals and objectives of the Source Water Protection Planning process.

10) The goals and objectives as set forth by the CWAP which has defined key actions and milestones.

11) The goal of zero discharge and zero emission for the nine designated chemical as set forth by the Binational Program to restore and protect the Lake Superior basin.

SCOPE AND SCALE: Because of the large geographic size of the Great Lakes and their basins, and the complexity of impairments and sources of those impairments, it is necessary to clearly identify both the scope and scale that can be managed by the TMDL process. It is also important to understand that the TMDL process functions through the use of a mathematical model that at best can only predict possible results, but not necessarily actual results.

First, the scope of the overall TMDL process within the lake and its basin should be defined. Beyond defining the impairments, it is important that both the causes and sources of the impairments be identified. Therefore, the initial scope should focus on three main categories as possible sources of impairment: tributaries, air deposition, and in-place or legacy pollutants. Under each one of these categories, additional sources can be further defined, such as point and nonpoint sources for tributaries, local and distant point and nonpoint sources for air deposition, and sites for in-place pollutants such as AOCs or Superfund sites. Each of those issues could then be addressed by the TMDL process within an identified scale.

MONITORING AND DATA: Because the Great Lakes are a very complex system, the need for sound, scientifically credible data is critical to being able to produce TMDLs that result in reasonable load allocations that fall within an acceptable confidence range. It is also important that the data used in the modeling component of a TMDL is scientifically sound and credible. That consideration is especially important because the loads that are to be allocated for control are in some cases regulatory.

It is also very important that the data be of high quality, since the implementation plans associated with the load allocations should reasonably result in water quality improvement and meet WQSs. COORDINATED PLANNING EFFORTS: Because of the many issues associated with maintaining and protecting the water quality of the Great Lakes and their associated basins, numerous planning efforts are currently ongoing. Some of these planning efforts were defined under the goals and objectives section of this document. Other planning efforts will include the TMDL implementation plans and any program activities that may or may not be incorporated into the TMDL implementation plans.

Effectively implementing this process will require committed leadership and the ability to develop and maintain good partnerships.

PARTNERSHIPS: To develop Great Lake TMDLs, and ensure effective implementation of the TMDL implementation plans, effective partnerships must be developed. To establish effective partnerships for both the development and the implementation of TMDLs within the Great Lakes and their associated basins, the following strategic approach is presented.

1) Identify the lead agency or agencies that will be responsible for developing and maintaining the needed partnerships for developing and implementing the TMDL process.

2) Identify the needed partners and define their role and responsibility to ensure the effective development and implementation of the TMDLs and the TMDL implementation plans.

3) Identify the partners in two major categories: those that would function in a statutory or regulatory mode and those that would function in a voluntary mode.

4) Evaluate the partners' resource capability in being able to carry out their defined roles and responsibilities. When there is a lack of resources, determine the options that might be available to assist or reinforce resource capabilities for partners.

5) Develop and define a forum through which partners can be brought together to exchange information, and work effectively to develop and implement TMDLs.

Components of a TMDL

Section 303(d) of the CWA, EPA's implementing regulations at 40 CFR Part 130, and the Water Quality Guidance for the Great Lakes System (40 CFR Part 132) describe the statutory and regulatory requirements for approveable TMDLs. The minimum components of a TMDL are outlined in Addendum A of this document and include the following:

1) Description of Waterbody, Impairment or Standard Violation, Pollutant of Concern, Pollutant Sources and Priority Ranking

2) Description of TMDL Endpoints -- Applicable Water Quality Standards and Numeric Water Quality Targets
3) Loading Capacity - Linking Water Quality and Pollutant Sources
4) Load Allocations (LAs)
5) Wasteload Allocations (WLAs)
6) Margin of Safety (MOS)
7) Seasonal Variation
8) Monitoring Plan for TMDLs Developed Under the Phased Approach
9) Implementation Plans (recommended under current policy)
10) Reasonable Assurances of Implementation
11) Public Participation
12) Submittal Letter

In addition, 40 CFR Part 132 provides specific requirements relating to TMDL development in the Great Lakes basin.

Revisions to the TMDL process are expected in the year 2000. New regulations have been proposed that will change what is required for both the Section 303(d) lists and for an approvable TMDL. Under the proposed regulations, the States are responsible for developing the list of impaired or threatened waters every two years (this requirement may change). Impairment is defined as those waters that do not meet the designated use or the appropriate WQS.

The Lakewide Management Plan process is outlined under the GLWQA of 1978. Under the GLWQA, as amended by the Protocols of 1983 and 1987, the United States and Canada (the Parties) agreed ". . . to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem." To achieve this purpose, the Parties agreed to develop and implement, in consultation with state governments, provincial governments, and tribes, LaMPs for open lake waters.

In the case of Lake Superior, the Lakewide Management Plan development effort has been led by the United States and Canada. As specified in Annex 2 of the GLWQA, the LaMP for Lake Superior is designed to reduce loadings of critical pollutants in order to restore 14 designated beneficial uses and prevent increases in pollutant loadings in areas where the specific objectives of the agreement are not exceeded. Moreover, the Specific Objectives Supplement to Annex I of the GLWQA requires the development of ecosystem objectives for Lake Superior. Pursuant to that charge, the Lake Superior LaMP embodies a systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses by seeking a balance between critical pollutant reduction and ecosystem sustainability in open lake waters and the watersheds that comprise the lake basin.

Comparison of the TMDL and the LaMP Processes

The TMDL and LaMP processes are fundamentally similar, but there are several key distinctions between them:

1) Both processes are intended to achieve clearly defined endpoints -- a WQS or numeric water quality target in the case of a TMDL, and a set of ecosystem objectives under the LaMP. However, the TMDL endpoints focus solely on WQSs, while the LaMP considers other ecosystem objectives in addition to numeric water quality targets. For example, the LaMP calls for the removal of restrictions on fish and wildlife consumption, prevention of bird or animal deformities or reproduction problems, and protection of the benthos. As a result, the LaMP process has identified over 20 critical pollutants to serve as the focus for the management activities, while a TMDL for the open waters of the lake will focus on only those pollutants that are linked to water quality standard exceedances.

2) Both processes require a documented status of the ecosystem.

3) Management planning to achieve ecosystem objectives is a key component of the LaMP. Implementation planning is recommended under the TMDL process and may be a required part of an approvable TMDL under the proposed regulations. However, planning is currently not the central focus of a TMDL.

4) Developing a direct link between pollutant load and achievement of the endpoint, often through water quality modeling, is a critical component of a TMDL. In contrast, the LaMP describes the relationship between loading and achievement of an ecosystem objective as a partnership effort involving the governments, tribes, and non-governmental sectors of the basin.

5) Both processes require an integrated monitoring plan for the lake.

6) Both processes require data, but the data are to be measured against different objectives.

7) The Lake Superior Binational Program goal of zero discharge is incorporated in the LaMP. This goal of zero discharge and zero emission goes beyond the TMDL requirement of allocating loads in such a way that WQSs are met.

In sum, the TMDL and LaMP processes are intended to achieve the common objective of restoring the Lake Superior ecosystem. However, a TMDL defines ecosystem protection more narrowly through the application of water quality standards and places great emphasis on understanding the relationship between pollutant load and achievement of the standard. In contrast, the LaMP defines ecosystem protection and restoration more broadly and places greater emphasis on pollution control planning and developing implementation targets.

4.0 Issues to Be Resolved

A number of key issues have been identified to better coordinate LaMP and TMDL activities (options for addressing each of these issues will be developed under the TMDL Strategy).

Issue 1: Identifying roles and responsibilities for each of the listed waters: tributaries, nearshore waters, open waters of the lake.

Issue 2: Should the lake be partitioned into segments that would be easier and more efficient to address with TMDLs?

Issue 3: Encourage consistency in 303(d) listing procedures among the States.

Issue 4: Maintain consistency in endpoint determinations (water quality standards) among the States.

Issue 5: Review the use of mass balance and other special studies on the lake with regard to their applicability to support a TMDL.

Issue 6: Integrate with other Programs (e.g., Source Water Protection Program).

Issue 7: Clarify the relationship between LaMP restoration and protection goals and TMDL endpoints (water quality standards).

Issue 8: Investigate options for addressing air deposition of TMDL pollutants.

Issue 9: Develop approaches for determining margin of safety when addressing fish consumption advisories.

Issue 10: Maintain consistency among the five Great Lakes.

Issue 11: Define the role of the Tribes in the TMDL process.

5.0 Strawman Framework for a Lake Superior TMDL Strategy

As a a means of generating discussion on the likely components of a Lake Superior TMDL Strategy, the following strawman framework is offered.

Process

To develop the TMDLs for the Great Lakes, the process will include:

1) Identify the impairments.

2) If at all possible, identify impaired segments.

3) Approve the listing of the segment under Section 303(d).

4) Generate the TMDL.

A) Determination of sources - While air deposition of mercury and PCBs may pose the largest portion of the load of these two pollutants to the lakes, other sources will have to be identified, including natural background. In addition, there are other portions of the lakes identified on the 1998 lists for impairments other than fish consumption advisories.

B) Determination of loads from the sources - Significant amounts of data already exist regarding the Great Lakes, much of it generated during the LaMP process. Additional information is being gathered regarding air deposition of mercury in the Devil's Lake Pilot Project. Data from this project, as well as other air deposition mercury projects, will be incorporated as generated in the development of any appropriate TMDL.

Numerous TMDLs are scheduled on tributaries to the various Great Lakes. These will certainly result in the generation of addition data regarding loading of pollutants to the Great Lakes, as well as result in lower loadings as the TMDLs are implemented.

Although much data exists, there are significant data gaps that have been identified. These include:

1) Relevant information on TMDLs or Mass Balance Activities for interstate or other waters that may contribute insight into TMDLs for Great Lakes listed waters.

2) Discussion of impairments listed in LaMPs and the TMDL lists, and the relationship to State Standards.

3) Air deposition data for mercury and PCBs in the Great Lakes basin

As the process moves forward, there will certainly be numerous data gaps noted. As they are noted, it will be important to determine if the data exists elsewhere, and if not, who should be working to gather the data (Feds, State, contractor, other, etc)

C) Determining the maximum load that will not cause a violation of WQS

D) Allocating the load to the various sources

E) Developing an implementation plan to ensure the TMDL is carried out

Time Frame -

A 15 year time frame is available to complete a TMDL. Is this timeframe consistent with state expectations?

Roles and Responsibilities -

Some states have written into their 303(d) lists that the U.S. EPA is responsible for developing the Great Lakes TMDLs for air deposition pollutants, while other states have made a more qualified statement.

> Federal role - The federal role in the Great Lakes TMDL process is at a minimum: 1) approve/disapprove 303(d) lists; 2) approve/disapprove the TMDLs. If the lists or TMDLs are disapproved, then the U.S. EPA has the responsibility to issue appropriate lists or TMDLs. However, the federal role will be much larger than that stated above. The U.S. EPA will take the lead on “open water” TMDLs, serve to facilitate the generation of the TMDLs, provide funding through various mechanisms, assist in data gathering (especially for air deposition pollutants), provide technical support, coordinate efforts among the states, serve as information repository, and provide legal analysis and support.
>
> State role - List impaired waters, take the lead on tributary water TMDLs, and provide support and data for “open water” TMDLs.

6.0 Next Steps in the TMDL Development Process

This document is only the first step in the process to develop a TMDL Strategy for Lake Superior. U.S. EPA envisions the following next steps in this process:

1) Gather comments on this strategy planning document and the issues identified in Section 4.0.

2) Convene regulators in the Fall of 2000 to begin discussions on the following:

    a) the outstanding issues identified in Section 4.0 of this document,
    b) plans for a Winter 2001 information meeting,
    c) plans for future stakeholder meetings,
    d) clarifying resource needs and availability, and
    e) investigating the formation of work groups.

3) Convene an information meeting in the Winter of 2001 to review information collected on pollutant load to the lake, including the preliminary results of the Devil’s Lake Mercury Pilot Study. Review changes to the TMDL regulations and guidance.

4) Convene a series of stakeholder meetings and/or workshops to inform the development of a

draft Lake Superior TMDL Strategy.

U.S. EPA has not yet developed a final schedule for these next steps. U.S. EPA welcomes comments on these proposed next steps, a schedule of activities, and any issues raised in this strategy planning document.

ADDENDUM A

REVIEW ELEMENTS OF TMDLs

Section 303(d) of the Clean Water Act (CWA) and EPA's implementing regulations at 40 CFR Part 130 and the Water Quality Guidance for the Great Lakes System (40 CFR Part 132) describe the statutory and regulatory requirements for approvable TMDLs. The following information is generally necessary for EPA to determine if a submitted TMDL fulfills the legal requirements for approval under Section 303(d) and EPA regulations, and should be included in the submittal package. Use of the verb "must" below denotes information that is required to be submitted because it relates to elements of the TMDL required by the CWA and by regulation.

1. Description of Waterbody, Pollutant of Concern, Pollutant Sources and Priority Ranking

The TMDL analytical document must identify the waterbody as it appears on the State/Tribe's 303(d) list, the pollutant of concern and the priority ranking of the waterbody. The TMDL submittal must include a description of the point and nonpoint sources of the pollutant of concern, including the magnitude and location of the sources. Where it is possible to separate natural background from nonpoint sources, a description of the natural background must be provided, including the magnitude and location of the source(s). Such information is necessary for EPA's review of the load and wasteload allocations which are required by regulation. The TMDL submittal should also contain a description of any important assumptions made in developing the TMDL, such as: (1) the assumed distribution of land use in the watershed; (2) population characteristics, wildlife resources, and other relevant information affecting the characterization of the pollutant of concern and its allocation to sources; (3) present and future growth trends, if taken into consideration in preparing the TMDL; and, (4) explanation and analytical basis for expressing the TMDL through *surrogate measures*, if applicable. *Surrogate measures* are parameters such as percent fines and turbidity for sediment impairments, or chlorophyl *a* and phosphorus loadings for excess algae.

2. Description of the Applicable Water Quality Standards and Numeric Water Quality Target

The TMDL submittal must include a description of the applicable State/Tribe water quality standard, including the designated use(s) of the waterbody, the applicable numeric or narrative water quality criterion, and the antidegradation policy. Such information is necessary for EPA's review of the load and wasteload allocations which are required by regulation. A numeric water quality target for the TMDL (a quantitative value used to measure whether or not the applicable water quality standard is attained) must be identified. If the TMDL is based on a target other than a numeric water quality criterion, then a numeric expression, usually site specific, must be developed from a narrative criterion and a description of the process used to derive the target must be included in the submittal.

3. Loading Capacity - Linking Water Quality and Pollutant Sources

As described in EPA guidance, a TMDL identifies the loading capacity of a waterbody for a particular pollutant. EPA regulations define loading capacity as the greatest amount of loading that a water can receive without violating water quality standards (40 CFR § 130.2(f)). The loadings are required to be expressed as either mass-per-time, toxicity or other appropriate measure (40 CFR § 130.2(I)). The TMDL submittal must identify the waterbody's loading capacity for the applicable pollutant and describe the rationale for the method used to establish the cause-and-effect relationship between the numeric target and the identified pollutant sources. In most instances, this method will be a water quality model. Supporting documentation for the TMDL analysis must also be contained in the submittal, including the basis for assumptions, strengths and weaknesses in the analytical process, results from water quality modeling, etc. Such information is necessary for EPAs review of the load and wasteload allocations which are required by regulation.

In many circumstances, a *critical condition* must be described and related to physical conditions in the waterbody as part of the analysis of loading capacity (40 CFR 130.7(c)(1)). The critical condition can be thought of as the worst case scenario of environmental conditions in the waterbody in which the loading expressed in the TMDL for the pollutant of concern will continue to meet water quality standards. *Critical condition*s are the combination of environmental factors (e.g., flow, temperature, etc.) that results in attaining and maintaining the water quality criterion and has an acceptably low frequency of occurrence. *Critical conditions* are important because they describe the factors that combine to cause a violation of water quality standards and will help in identifying the actions that may have to be undertaken to meet water quality standards. Stream design guidelines for Great Lakes tributaries are specified under 40 CFR Part 132, Appendix F.

4. Load Allocations (LAs)

EPA regulations require that a TMDL include LAs, which identify the portion of the loading capacity allocated to existing and future nonpoint sources and to natural background (40 CFR. 130.2(g) and 40 CFR 132, Appendix F). Load allocations may range from reasonably accurate estimates to gross allotments (40 CFR. 130.2(g)). Where it is possible to separate natural background from nonpoint sources, load allocations should be described separately for background and for nonpoint sources.

If the TMDL concludes that there are no nonpoint sources and/or natural background, or the TMDL recommends a zero load allocation, the LA must be expressed as zero. If the TMDL recommends a zero LA after considering all pollutant sources, there must be a discussion of the reasoning behind this decision, since a zero LA implies an allocation only to point sources will result in attainment of the applicable water quality standard, and all nonpoint and background sources will be removed.

5. Wasteload Allocations (WLAs)

EPA regulations require that a TMDL include WLAs, which identify the portion of the loading capacity allocated to existing and future point sources (40 CFR 130.2(h) and 40 CFR 132, Appendix F). If no point sources are present or if the TMDL recommends a zero WLA for point sources, the WLA must be expressed as zero. If the TMDL recommends a zero WLA after considering all pollutant sources, there must be a discussion of the reasoning behind this decision, since a zero WLA implies an allocation only to nonpoint sources and background will result in attainment of the applicable water quality standard, and all point sources will be removed.
In preparing the wasteload allocations, it is not necessary that each individual point source be assigned a portion of the allocation of pollutant loading capacity. When the source is a minor discharger of the pollutant of concern or if the source is contained within an aggregated general permit, an aggregated WLA can be assigned to the group of facilities. But it is necessary to allocate the loading capacity among individual point sources as necessary to meet the water quality standard.

The TMDL submittal should also discuss whether a point source is given a less stringent wasteload allocation based on an assumption that nonpoint source load reductions will occur. In such cases, the State/Tribe will need to demonstrate reasonable assurance that the nonpoint source reductions will occur within a reasonable time.

6. Margin of Safety (MOS)

The statute and regulations require that a TMDL include a margin of safety to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA § 303(d)(1)(C), 40 CFR §130.7(c)(1), and 40 CFR 132, Appendix F). EPA guidance explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading set aside for the MOS must be identified.

7. Seasonal Variation

The statute and regulations require that a TMDL be established with consideration of seasonal variations. The method chosen for including seasonal variations in the TMDL must be described (CWA § 303(d)(1)(C), 40 CFR § 130.7(c)(1)).

8. Monitoring Plan for TMDLs Developed Under the Phased Approach

EPA's 1991 document, *Guidance for Water Quality-Based Decisions: The TMDL Process* (EPA 440/4-91-001), recommends a monitoring plan when a TMDL is developed under the phased approach. The guidance recommends that a TMDL developed under the phased approach also should provide assurances that nonpoint source controls will achieve expected load reductions. The phased approach is appropriate when a TMDL involves both point and nonpoint sources and the point source is given a less stringent wasteload allocation based on an assumption that nonpoint source load reductions will occur. EPA's guidance provides that a TMDL developed under the phased approach should include a monitoring plan that describes the additional data to be collected to determine if the load reductions required by the TMDL lead to attainment of water quality standards.

9. Implementation Plans

On August 8, 1997, Bob Perciasepe (EPA Assistant Administrator for the Office of Water) issued a memorandum, "New Policies for Establishing and Implementing Total Maximum Daily Loads (TMDLs)," that directs Regions to work in partnership with States/Tribes to achieve nonpoint source load allocations established for 303(d)-listed waters impaired solely or primarily by nonpoint sources. To this end, the memorandum asks that Regions assist States/Tribes in developing implementation plans that include reasonable assurances that the nonpoint source load allocations established in TMDLs for waters impaired solely or primarily by nonpoint sources will in fact be achieved. The memorandum also includes a discussion of renewed focus on the public participation process and recognition of other relevant watershed management processes used in the TMDL process. Although implementation plans are not approved by EPA, they help establish the basis for EPA's approval of TMDLs.

10. Reasonable Assurances

EPA guidance calls for reasonable assurances when TMDLs are developed for waters impaired by both point and nonpoint sources. In a water impaired by both point and nonpoint sources, where a point source is given a less stringent wasteload allocation based on an assumption that nonpoint source load reductions will occur, reasonable assurance that the nonpoint source reductions will happen must be explained in order for the TMDL to be approvable. This information is necessary for EPA to determine that the load and wasteload allocations will achieve water quality standards.

In a water impaired solely by nonpoint sources, reasonable assurances that load reductions will be achieved are not required in order for a TMDL to be approvable. However, for such nonpoint source-only waters, States/Tribes are strongly encouraged to provide reasonable assurances regarding achievement of load allocations in the implementation plans described in section 9, above. As described in the August 8, 1997 Perciasepe memorandum, such reasonable assurances should be included in State/Tribe implementation plans and "may be non-regulatory, regulatory, or incentive-based, consistent with applicable laws and programs."

11. Public Participation

EPA policy is that there must be full and meaningful public participation in the TMDL development process. Each State/Tribe must, therefore, provide for public participation consistent with its own continuing planning process and public participation requirements (40 CFR § 130.7(c)(1)(ii)). In guidance, EPA has explained that final TMDLs submitted to EPA for review and approval must describe the State/Tribe's public participation process, including a summary of significant comments and the State/Tribe's responses to those comments. When EPA establishes a TMDL, EPA regulations require EPA to publish a notice seeking public comment (40 CFR § 130.7(d)(2)).

Inadequate public participation could be a basis for disapproving a TMDL; however, where EPA determines that a State/Tribe has not provided adequate public participation, EPA may defer its approval action until adequate public participation has been provided for, either by the State/Tribe or by EPA.

12. Submittal Letter

A submittal letter should be included with the TMDL analytical document, and should specify whether the TMDL is being submitted for a *technical review* or is a *final submittal*. Each final TMDL submitted to EPA must be accompanied by a submittal letter that explicitly states that the submittal is a final TMDL submitted under Section 303(d) of the Clean Water Act for EPA review and approval. This clearly establishes the State/Tribe's intent to submit, and EPA's duty to review, the TMDL under the statute. The submittal letter, whether for technical review or final submittal, should contain such information as the name and location of the waterbody, the pollutant(s) of concern, and the priority ranking of the waterbody.