HABITAT EVALUATION:
GUIDANCE FOR THE REVIEW OF
ENVIRONMENTAL IMPACT ASSESSMENT DOCUMENTS

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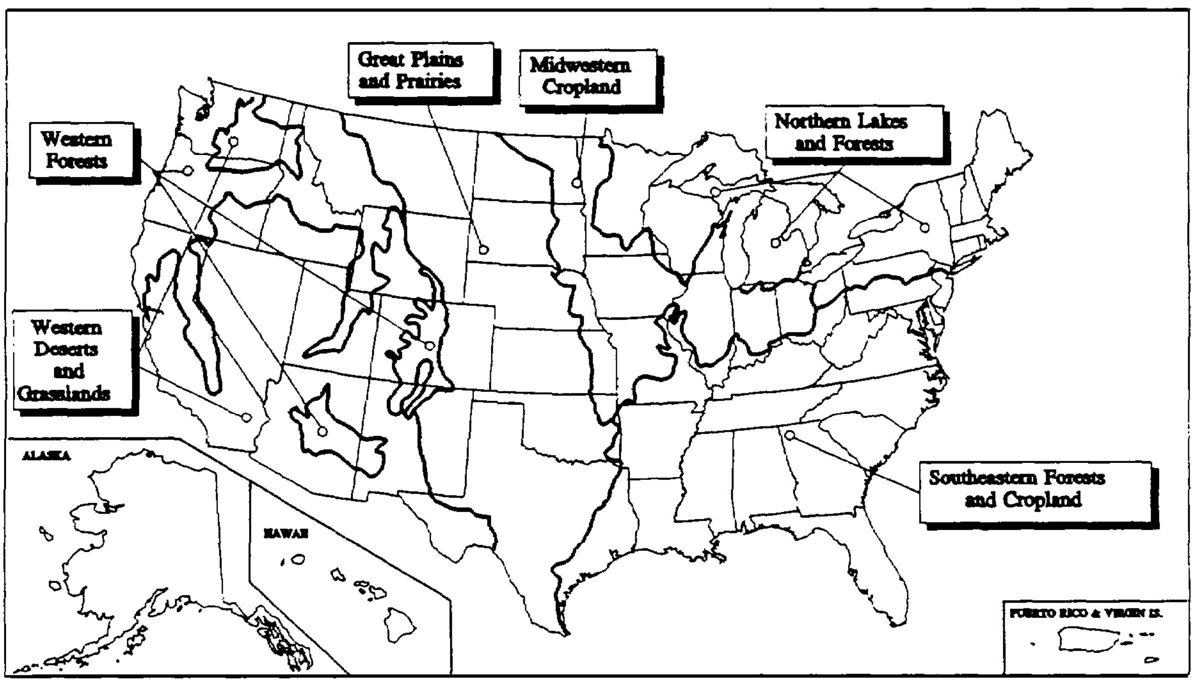
INTRODUCTION

Based on the recent Science Advisory Board (SAB) report *Reducing Risk*, the U.S. Environmental Protection Agency (EPA) has concluded that habitat alteration and destruction are among the greatest risks to ecological and human welfare. The SAB specifically recommends that EPA consider reducing ecological risk to be as important as reducing human health risk. The recommendation states that EPA should protect ecosystems because they are essential to human health and a sustainable economy, and because they have intrinsic value.

This document is designed to assist NEPA reviewers in evaluating the ecological risks associated with the impacts of federal activities. The information provided will assist NEPA reviewers in developing informed comments for project scoping, EIS review, and section 309 analyses related to the issues of habitat loss and degradation. In particular, this document is designed to help reviewers recommend mitigations to prevent the loss of habitats. This document also should be useful to other EPA program offices and other federal agencies.

The first part of this document is a general discussion of habitat issues relevant to environmental analysis review; it should be read before the regional discussions. This section provides a basic description of habitat and its values, and of the degrading activities, impacts, and mitigations relevant to habitats in general. Eight *Regional Habitat Evaluation* sections, representing the six major habitat regions of the conterminous United States plus Alaska and Hawaii (see figure below), provide more specific



Habitat Regions of the United States

information on habitats of concern, values and trends, degrading activities and impacts, and potential mitigations. Specifically, each regional discussion includes a list of habitats of concern, a table of activities impacting habitats, and recommended mitigations for habitat conservation. Because each regional section considers only the major impacts affecting habitats in that region, reviewers should refer to different regions for discussions of other impacts that may be relevant to their specific project reviews. At the end of each section, basic guidelines are provided to aid in the environmental project reviewer's consideration of the full range of habitat impacts.

This document is not intended to serve as complete guidance or as a simplified checklist for environmental project review. In particular, this document focuses on activities occurring in the terrestrial environment, although impacts of these activities on wetlands and aquatic systems are also considered. Additional information on activities directly degrading aquatic systems should be reviewed where appropriate. It is expected that specific habitat issues relevant to the project site will be addressed, and that appropriate information on the ecology of the project site will be obtained. A list of useful institutional contacts is included with each regional discussion.

Habitat Conservation

Habitats are those environments or ecosystems that provide substantial ecological values and services such as fish and wildlife populations, nutrient cycling, water purification, and climate control. All natural areas contain definable units that can be called either ecosystems or habitats. In this document, the term habitat is equivalent to ecosystem and includes both the physical and biological components of the environment. All habitats are important for the conservation of ecological values at their specific location. However, certain habitats, and types of habitat, can be designated as "of special concern." For the purpose of this document, habitats of concern are defined as those sensitive environments whose degradation or loss results in significant diminution of ecosystem integrity or ecological values. The habitats of concern listed in this document represent the most obvious cases of loss of ecological values and services on a regional scale.

The following general discussion of habitat conservation begins with a summary of the important issues and steps involved in assessing habitats, follows with a working definition of habitats of concern, and continues with discussions of the values and services provided by habitats, the activities affecting habitats, the types of impacts caused by these activities, and potential mitigation measures to address these impacts on habitats.

Habitat Evaluation Methodology

The definition of habitat in this document is based on ecosystem values and functions. Therefore, it is necessary to present habitats as classes of similar ecosystems that contain a known set of ecological values and functions. The habitats discussed in this report are broad vegetation-based categories that include a range of more specific ecosystem types. While this document will categorize habitats and identify individual impacts, it must be remembered that each habitat is unique. An individual habitat must be evaluated in the context of its specific geographic location to determine its true value. At the same time, the effect of alterations to a habitat by degrading activities must be considered in terms of the impact on the entire landscape. Therefore, an ecological perspective is essential for the adequate consideration of habitat issues. This approach requires that the interactions of ecological components be considered, and that the unique characteristics of each ecosystem be evaluated. The following considerations should be central to any process of habitat evaluation:

- Apply an **ecosystem-level perspective** that considers the full range of interactions among habitat components.
- Assess the **cumulative effects** that arise from the additive and synergistic impacts of several degrading activities occurring over time or space.
- Analyze the true **effectiveness of mitigation** measures in conserving natural habitats and their ecological values.

It is common for habitat considerations to be neglected within environmental analysis because of the difficulties of individual site-specific assessments. To better address the consideration of impacts to habitat in environmental analyses, regional information on the impacts to habitats of concern and their mitigation can be used. Therefore, the sections that follow describe general habitats that are threatened with loss or degradation from human activities. The condition of these habitats, the activities that affect them, and potential mitigations for the impacts that degrade them are discussed.

The application of this regional information should improve the quality of environmental analyses of all kinds. Along with an ecosystem perspective, attention to cumulative effects, and measures of mitigation effectiveness, the following steps can be used to incorporate landscape-scale considerations into both regional-level and site-level environmental analyses:

Step 1. Review the status and trends of habitats in the regions under consideration.

Step 2. Identify habitats of concern for the region that may occur at the site.

Step 3. Analyze the impacts of all activities on the functions and values of these habitats.

Step 4. Derive mitigation measures to eliminate or ameliorate the impacts on habitats of concern.

Habitats of Concern

Virtually all of the natural environments in the United States have been degraded to some extent by the impacts of human activities. Even relatively pristine ecosystems are affected by the loss of contiguous habitats and other changes to the landscape. Therefore, the most important criterion for designation of a natural area as a priority concern is the importance of a habitat to the ecological integrity (i.e., the health and natural functioning) of the larger landscape or eco-complex (*sensu* Polunin and Worthington 1990). In this way, a habitat may be thought of as analogous to a "keystone species" within a biotic community. For practical reasons, rarity is often the criterion by which a habitat's value is determined. However, in assessing the value of a habitat, rarity, ecological functioning, regional diversity, and other important attributes also should be considered.

Definition of Habitat

The standard definition of *habitat* is based in the environment of individual species; for example,

> "Habitat is the environmental setting in which an animal or plant normally lives, grows, and reproduces" (NRC 1982);
>
> and
>
> "Habitat is the area which provides direct support for a given species, population, or community. It includes all environmental features that comprise an area such as air quality, water quality, vegetation and soil characteristics and water supply (including both surface and ground water)" (Fish and Wildlife Service, FR 46(15):7662-7663).

Although this definition has been important to the management and preservation of many individual species, it is inadequate for regional or global biodiversity protection efforts. Indeed, national inventories of species-specific habitat are not practical for most species, and in fact have been accomplished only for the critical habitats of endangered species (Flather and Hoekstra 1989). The need to address the conditions of a wide range of species, and biological diversity in general, requires an ecosystem approach to habitat inventory. For the purpose of this document, the following definition is used:

> Habitat - a natural environment composed of both living organisms and physical components that function together as an ecological unit.

In many contexts, this definition is synonymous with *ecosystem* or *sensitive environment*. It assumes that the natural condition of an environment is preferred because it represents a system that through evolution is most likely to provide the desired values of biological diversity and ecosystem functioning. Although the difficulties in classifying habitats or ecosystems have prevented the completion of adequate national inventories, different classifications have been used for specific purposes or for restricted locations. The National Wetlands Inventory of the U.S. Fish and Wildlife Service uses the widely accepted Cowardin classification system for wetlands and deepwater habitats (Cowardin et al. 1979). The U.S. Forest Service has used a variety of classification systems including the Forest and Range Environmental System (FRES) (Garrison et al. 1977) based on Küchler Potential Natural Vegetation units (1964) and Bailey Ecoregions (1976). The U.S. EPA has recently defined general classes of ecological resources for all habitat types as part of its Environmental Monitoring and Assessment Program (EMAP) (Hunsaker and Carpenter 1990). Greater resolution in habitat classification has been obtained by state natural heritage programs in coordination with The Nature Conservancy. Extensive natural heritage databases that once consisted of only species element occurrences now include "community" elements. At present, each state has a community classification, and many are working toward regional classifications. If this is accomplished, there will someday be national coverage of community types from which to base a quantitative assessment of habitats (Larry Master, personal communication).

Given the mixture of classification systems, systematic status and trends information is not available for most habitats (Southerland and Hirsch 1989). However, considerable information on the status and trends of individual species is available and can be useful in characterizing habitat status and trends. In fact, the Fish and Wildlife Service (FR 46(15):7662-7663) has developed the concept of evaluation species upon which they base analyses of environmental impact. The evaluation species include species of high public interest and economic value, and species that provide broad ecological representation. Environmental analyses can use identification of such "species of concern" as a useful starting point for identifying habitats of concern. Throughout this document, species status and trends will be included to the extent they reflect habitat conditions, but it must be remembered that they represent only a few of the many species in each habitat, all of which are required to maintain a healthy ecosystem and a full range of values and services.

General Habitat Types

Before colonization by Europeans, North America was covered from the Atlantic Ocean to west of the Mississippi River with diverse eastern deciduous forests of large oak, chestnut, beech, and maple; farther west spread a lush tallgrass prairie; beyond that was a semi-arid shortgrass prairie with regional deserts, grasslands, and coniferous forests (Norse 1990b). A nearly unlimited number of unique habitats existed within these regions, varying with soil conditions and topographic differences. The exploitation and manipulation of land by human activities has since eliminated or modified many of these habitats. This document uses the major land types of *forests*, *rangelands*, and *wetlands* to facilitate the identification of more specific habitats of concern. It focuses on habitat types that are repeated across the region and does not consider individual plant communities that vary with exact geographic location. The scale of these habitat types varies, and although a medium scale is applied in this document, it is important to remember that the following additional classes of habitats of concern should be considered in individual environmental analyses:

- Individual plant communities (e.g., those compiled by state natural heritage programs).
- Transitional habitats and functional mosaics of habitat, e.g., the sandhill-scrub-lake complex of the natural upland hardwood forest of Florida (Noss 1987).
- Landscape-scale ecosystems, or eco-complexes (e.g., the Chesapeake Bay watershed).

Values and Services of Habitats

Habitats provide the full complement of ecological values and services contained in a naturally evolved ecosystem. These include many services that have economic benefits, as well as aesthetic and moral values. All individual species values, overall biodiversity values, and ecosystem services are encompassed in ecological integrity. Therefore, it should be the objective of habitat conservation efforts to preserve the ecological integrity of habitats.

Species Values

Individual species are the values most often associated with habitats. Historically, commercial timber species and crop plants, and game animals and sport fish have been the most prized species; subsequently, noncommercial plants, nongame birds, endangered species, and other popular species have received attention. Those interested in species preservation are now viewing habitat conservation as a means of protecting species "wholesale" (Waller 1991). This is in contrast to the single-species approach required by the Endangered Species Act, often referred to as "emergency rescue operations" (as in the cases of the California condor and black-footed ferret). The best example of the habitat-based approach is the effort of The Nature Conservancy which has adopted a "coarse filter" approach to protecting species based on protecting the natural communities in which they reside. This approach provides protection for the majority of species, including unknown and undescribed ones.

The most visible values of any habitat are the many plant species that make it up. Plants are prized for their intrinsic value and for their roles in ecosystem functioning. Recently, previously ignored species are receiving attention for their contributions to genetic diversity. There is also ample evidence of the importance of habitat to animal populations. Among state wildlife and fish management agencies, habitat loss ranked first in national priority for all species, for big game, for small game, and for waterfowl (Flather and Hoekstra 1989). Habitat also ranked second to barriers to migration in importance for sustaining anadromous fish populations. Wildlife management efforts have had their greatest success with species (big game and some endangered species) for which habitat is abundant. Species whose habitat is declining in amount and quality are currently, and will continue to be, most threatened with extirpation (Thomas 1990).

Biological Diversity

The interest in preserving particular species has broadened in recent years to encompass a concern for all biotic resources under the general term "biological diversity." The Office of Technology Assessment (1987) defines biological diversity as

> "The variety and variability among living organisms and the ecological complexes in which they occur";

while the Keystone Dialogue on Biodiversity on Federal Lands (1990) defines biological diversity as

> "The variety of life and its processes."

Both of these definitions emphasize that biological diversity, or biodiversity, entails all ecosystem components and includes the myriad functions and values provided by the living organisms in each habitat. The number and relative frequency of items that make up biological diversity may be organized along the continuum from genes to species to ecosystems. The overall amount of genetic diversity is decreased when species diversity is lowered, as is species diversity when ecosystem diversity is lowered. For this reason, habitat loss and ecosystem degradation are the principal causes of reductions in biological diversity. Essentially, the conservation of habitat is the conservation of the ecological complexes that constitute biological diversity. In addition, the preservation of biological diversity may be the best means of protecting overall biological integrity and ecological health. Preserving biodiversity means maintaining the integrity of the genetic structure within populations, the richness of species within ecosystems, and the mosaic of ecosystems within the landscape (Norse 1990b).

Ecosystem Services

Although the conservation of individual species and overall biodiversity are essential to maintaining the ecological integrity of a habitat, a wide range of ecosystem functions must also be protected. Using a broad definition, habitat, like the ecosystem, is characterized by a particular energy flow, nutrient cycling, and capacity for self-perpetuation (given radiant energy from the sun). The services that ecosystems perform include serving as a store or sink for energy or materials, providing a pathway for nutrient transport, acting as a buffer against chemical changes, and producing the natural resources people use such as minerals, wood, food, water, and air (Hollis et al. 1988). A comprehensive list of ecosystem values is shown in the accompanying box.

Ecosystem Values[1]

Climate control:
- CO_2 sequestration
- evapotranspiration
- shading

Geomorphological control:
- wave and wind buffering
- erosion control
- sediment trapping
- soil building

Water supply:
- groundwater recharge
- floodflow alteration
- water supply

Energy and nutrient exchange:
- energy fixation
- carbon uptake
- nutrient uptake

Purification of resources:
- sediment/toxicant retention
- nutrient removal/transformation
- pollutant detoxification

Biotic resources:
- biotic productivity and food chain support
- genetic conservation of biodiversity
- fisheries
- wildlife diversity/abundance
- aquatic diversity/abundance
- aesthetics/cultural heritage

[1]Adapted from Race and Christie (1982), Adamus et al. (1987), Hinckley (1990), and Nash (1991).

Activities Impacting Habitats

After identifying the habitats of concern, the next important step is the linking of these habitats to the activities that cause their degradation or loss. The following major activities may cause the degradation or loss of habitats:

- Land conversion to industrial and residential land use.
- Land conversion to agriculture.
- Land conversion to transportation.
- Timber harvesting practices.
- Grazing practices.
- Mining practices.
- Water management practices.
- Military, recreational, and other activities.

Environmental analyses of these activities arise during both broad programmatic reviews and specific project environmental impact statements. The following common projects entail significant impacts to habitats and may require federal review:

- Community and public land use development, including planning, regulation, and federal funding for building construction and highway development.

- Renewable resource use and development (logging and grazing) on public lands or requiring permits.

- Energy production, including petroleum, natural gas, and coal development, extraction, generation, transmission, and use.

- Non-energy mineral resource development, processing, management, transport, and use.

- Water projects and permits for wetland modification.

- Natural resources conservation, including protection of environmentally critical areas.

This document focuses on the direct physical effects of the aforementioned activities on habitat extent and quality. However, another important source of impacts on habitat is the contamination of ecosystems from the pollution of the air, water, and land. Habitat pollution is addressed, in part, by the air quality, water quality, and hazardous substances programs of federal and state regulatory agencies. Therefore, habitat impacts from the generation of toxic and waste materials from manufacturing processes and fossil fuel combustion are not specifically addressed in this document. The following are examples of activities contributing to the contamination of habitats that should be added to the considerations in this document when a complete environmental analysis is prepared:

- Industrial and municipal discharges into water (e.g., toxic chemicals and conventional pollutants) and emissions into the air (e.g., acid deposition, gaseous phytotoxicants such as ozone, and global ozone depleting and greenhouse gases).

- Industrial and municipal waste dumps and landfills (e.g., asbestos and plastics in the marine environment).
- Agricultural contamination (e.g., pesticide spraying and nutrient discharges from cultivated fields and livestock feedlots).
- Mining waste discharges (e.g., mercury, arsenic, cyanide, crude oil, drilling muds, and saline-produced waters).
- Military accidental releases (e.g., nerve gas and plutonium).

The following sections briefly discuss the history and impacts of the major activities on habitats.

Land Conversion

The conversion from one land use to another is the activity most severely affecting terrestrial environments. The type of land conversion depends on the end use of the land. In each case, the original natural characteristics of the land are eliminated, and the associated ecological values are modified to varying degrees. Urban conversions, as well as other large industrial and commercial development projects, severely alter natural conditions, seriously disrupting ecosystem functions and eliminating most ecological values. Residential development in suburban and rural areas usually maintains some plant and wildlife values while disrupting the natural ecosystem processes of the area. Similarly, conversion to traditional agriculture alters the natural vegetation and ecological processes while still providing some hedgerow areas for wildlife populations. Large-patch industrialized agriculture, however, usually removes all wildlife habitat. Conversions to industrial, residential, and agricultural uses occur on many scales, but often cover very large areas. In contrast, conversions to highways, railways, and power lines affect terrestrial environments more by fragmentation than by total area converted. Landfills and the development of recreational areas are other kinds of land use conversions, but ones that cover relatively small areas.

Land Conversion to Industrial and Residential Land Uses

Conversion of natural environments to industrial, commercial, and residential land use continues to increase with population and with the general suburbanization of many previously natural areas. The large urban areas of the east and west coasts continue to grow, reducing the natural areas in the corridors between them. Land conversion due to infrastructure construction and landfills also contributes to the development pressure on natural areas near urban centers. Urban growth is most rapid in the Sun Belt states.

Urban and suburban conversion of terrestrial environments is also occurring throughout the country as "spinoff development" following new road construction. Even in areas of relatively little or no overall population growth (such as the Northeast), spinoff development is a major cause of forest fragmentation and the decline of wildlife and bird populations. This effect is augmented by the increasing frequency of second home development in previously undeveloped regions.

Arid environments in the Southwest are rapidly being converted to urban and residential uses as a result of population growth. The Southern California region is a classic example of suburban sprawl where roadways, residential communities, and commercial development have expanded into previously pristine environments. Many underappreciated desert habitats are at risk because of this continued land conversion. Riparian areas are another environment at risk in the West from land conversion to industrial and residential development. Because of their proximity to water and their desirability for industrial and residential use, riparian areas are being disproportionately destroyed. Also because of their proximity to water, riparian areas are critical for many migratory bird and wildlife species.

Land Conversion to Agricultural Uses

The United States uses a large part of its available land area for livestock and crop production, an area totaling more than 900 million ac (U.S. EPA 1989). Over 400 million of these ac. are classified as cropland. More than 50% of this area is in the corn and wheat growing regions of the Midwest Cropland and Great Plains and Prairies Habitat Regions. Land conversion to agriculture has stabilized in recent years, and much of the conversion to urban uses is now occurring on old agricultural lands. Conversion to agriculture continues to be a regional problem depending on the pricing variability of specific crops. For example, bottomland hardwoods in the South have recently suffered from extensive conversion to soybeans.

Although total agricultural acreages are not changing, many important wildlife habitats are being lost as a result of large-patch agriculture, which causes the elimination of fence rows and ditch banks. Current agricultural practices, and certain "conservation" programs, provide incentives for cultivating previously uneconomical areas. For example, the construction of grass waterways in riparian areas is destroying wildlife habitat rather than conserving it.

The loss of riparian and bottomland hardwoods to agriculture in the Southeast represents one of the most significant losses of ecological values of terrestrial environments. Similarly, the conversion of wetlands and adjacent grasslands in the central and western United States is another impact that has had serious consequences for ecological values, in particular waterfowl populations in the Prairie Pothole Region and along the Pacific and Mississippi Flyways.

Land Conversion to Transportation Uses

Construction of highways, railways, and power line right-of-ways contributes to the degradation of terrestrial habitats, especially in less developed areas. Although the actual areas converted are small (27 million ac) the fragmentation of habitats is often severe (Frey and Hexem 1985). Powerlines and other transportation routes can be described as "disturbance corridors" that disrupt the natural, more homogeneous landscape (Barrett and Bohlen 1991). In forested environments, these disturbances cause (1) dramatic physical disruption to the continuous vegetative community; (2) disruption to the structure and function of wildlife habitat; and (3) impacts to resident wildlife, which must negotiate, tolerate, and cope with the habitat barriers. In addition, disturbance corridors created by forest fragmentation provide habitat for early successional plant and animal species. They replace forest trees with grasses and shrubs so that forest-interior species cannot nest. While they provide dispersal routes for small mammals such chipmunk and white-footed mice, they present barriers to many species.

The impacts of highway construction also represent an important problem in cumulative impact assessment. Although individual road segments are usually evaluated for potential environmental impact, it is actually the combined effect of the entire highway system that most seriously degrades terrestrial and wetland environments. In addition, the cumulative impact of several highway systems can seriously disrupt migratory pathways. As mentioned above, the building of roads is invariably accompanied by additional land conversions to industrial or residential use.

Both forested and nonforested environments can be disrupted by fragmentation due to highway construction. However, the dense canopy structure of certain shrublands may be most severely impacted by fragmentation. An example is the fragmenting of pocosin wetlands and uplands in the Southeast. Because of the scale at which many pocosin inhabitants move, highway development can effectively isolate much of the pocosin fauna.

Timber Harvesting

Since the early 1600s, 20 to 40% of the nation's original forest cover has been converted to other land uses, and much of what remains has been substantially altered as a result of past logging. Regeneration of timbered areas is increasing forest acreages in the East, but these numbers are more than offset by timber harvests in the West. Many of the remaining forests of the United States are being altered by timber harvesting practices that fragment, simplify, and degrade natural forests. The combination of clear cut logging and road building increases forest fragmentation and soil erosion. The clear-cut natural stands are often replaced with fewer and different tree species resulting in the loss of old-growth trees and natural forest habitats essential to a wide variety of wildlife.

Forest habitats are the forum for the most acute biodiversity issues facing the nation, including (1) decreases in contiguous old-growth forest that support the spotted owl in the Northwest, (2) the loss of old pines needed by the red-cockaded woodpeckers in the Southeast, (3) increased habitat fragmentation and forest edge causing declines in forest-interior songbirds, and (4) increasing ungulate populations in the East and Midwest (Waller 1991). These problems are primarily the result of clear-cut logging and the institution of short-rotation single-species plantations. All timber harvesting activities affect forests in two ways (Cutter et al. 1991):

- Like natural fires, timber harvesting allows sunlight to reach the ground and stimulate new growth, while the slash (limbs too small to use) contributes to increased nutrient release. Thus, like fire, harvesting is a catastrophic but temporary disruption that removes large amounts of soil, nutrients, and biomass from the ecosystem, changes water yields, and increases stream temperatures.

- Unlike natural disturbances, timber harvesting involves road building and the use of heavy equipment on the land; this causes damage and compaction to the soil surface and accelerates soil erosion beyond the rates following fires. Especially along steep slopes, surface erosion and landsliding produce heavy sediment loads to streams, degrading aquatic habitats and damaging fish and invertebrate populations; the loss of biomass in the form of logs slows reestablishment of new growth, and the lack of fire may retard regrowth from fire-adapted seeds.

The major impacts of timber harvesting on forest degradation and loss include four major problem areas that can be addressed on a national or regional basis:

- Loss of old-growth forests.
- Effect on critical ecosystems (such as Greater Yellowstone).
- Decrease in roadless areas or wildlands.
- Impacts of silvicultural practices (such as clear cutting).

Grazing

Widespread devastation of rangelands resulted from uncontrolled overgrazing between 1880 and 1935, and the damage was amplified by the drought years of the 1930s (Branson 1985). The enactment of the Taylor Grazing Act of 1934 reduced grazing pressure at that time. With the advancement of range management science and the moist years following 1960, range vegetation improved considerably. However, the U.S. Forest Service (1989) reports that 21% of its rangelands were still in "unsatisfactory" condition. The Bureau of Land Management (1989) reports that BLM rangeland condition is 33% good or better, 38% fair, and 13% poor.

Although the total area of rangeland has remained relatively constant, the condition of the range ecosystems has varied considerably with competition by livestock for forage and other factors. Cattle, sheep, and wild horses and burros have contributed to reduced forage and to changes in vegetation composition on the majority of U.S. rangelands. Grazing and fire suppression have allowed brush species to replace many of the grass forage species on 200 million ac of the Southwest (National Association of Conservation Districts 1979). As with forest habitats, the fragmentation of rangeland vegetation can negatively affect native fauna and ecosystem health.

Unfortunately, traditional rangeland improvement measures often run counter to wildlife conservation. Herbicides reduce vegetation diversity, as do practices that till under sites and convert vegetation to nonnative species, usually replacing pinyon juniper with exotic grasses. Management of brush invasion in the southwestern deserts, savannas, and southern Great Plains is perhaps the greatest problem affecting rangeland wildlife. While deer and turkey populations have increased, native range forage is reduced by the invasion of mesquite, juniper, cacti, acacia, sand sagebrush, creosote bush, tarbush, whitebrush, yucca, and others. Mechanical or chemical reduction of these scrubs, as well as sagebrush in the Northern Plains, decreases forage for many species including prairie chicken, sage grouse, quail, and pronghorn.

Grazing is also detrimental to hardwood forests, riparian habitats, and areas where livestock compact root systems or increase erosion. In general, grazing reduces structural diversity of forest understory (by eliminating plants, altering species composition, modifying growth form, and shifting seral stages) and can negatively impact forest bird communities. Of particular concern are the impacts of grazing on forested riparian zones, which support the majority of species in the rangeland environment.

Mining

Millions of hectares of marginal and barren land can be found in the United States, much of it due to mining activity. These areas are a source of acid mine drainage, surface runoff, erosion, and sedimentation, which create water pollution and land degradation problems. Mining activities leave a harsh environment for vegetation because of the lack of nutrients and organic matter, low pH, low water-retaining capacity, toxic levels of trace metals, compaction, and poor physical conditions of spoil material (Sopper 1988).

It is important to note that mining often occurs on the mountain-plain ecotone, an area of special importance to wildlife. Nonetheless, mining disturbs relatively less land area than other activities affecting terrestrial environments. Only 5.7 million ac were disturbed between 1930 and 1980 by surface mine excavation, subsidence from underground workings, and disposal of mining wastes. Additional areas have been impacted by haulroads, reservoirs, and railroads and highways to mining properties. Stream habitats have been affected by acid drainage and sedimentation. The greatest potential for increased mining impacts exists in the area of exploration and extraction of fossil fuels.

Nearly half of all U.S. land used for mining is concentrated in the states of Pennsylvania, Kentucky, West Virginia (2% of each state) or in Ohio, Illinois, and Indiana (1% of each state). California and Florida have also mined more than 250,000 ac (Johnson and Paone 1982). Intense mining also occurs in the Arizona copper region and the northern Minnesota's Mesabi Iron Range. Among federal lands, 732 million ac are available for leasing to surface and subsurface mineral development, the majority in the west and Alaska; currently, 95 million ac are leased to oil and gas, 2 million to geothermal, and 1.3 million to coal (USDA Forest Service 1989).

Mining impacts are substantial but variable depending on the mining method, the mineral, the processing technology, and the ecological nature of the site. Impacts include destruction or impairment of fragile ecosystems and wildlife habitats, contamination of surface and subsurface water supplies and soils from toxic chemicals and radioactivity, and adverse effects on scenic values.

Water Management

Damming activities, impoundments, and water diversions for municipalities, industry, and agriculture severely affect the natural water supply, resulting in the destruction of terrestrial, wetland, and aquatic environments. In particular, the reduction of streamflow from diversions of water for other uses adversely affects riparian habitats in the Southwest. The Corps of Engineers stream channelization projects affect large areas of both terrestrial and aquatic environments. In fact, few streams or waterways still run free to the ocean without diversion or management that affects their natural flow. The inundation of large areas for flood control and water supply has decreased in recent years, but still constitutes a major impact on local environments. In the Mississippi Basin (mid-south Alabama, Tennessee, eastern Texas, and Oklahoma), considerable acreage of bottomland hardwoods was lost to reservoir development between 1962 and 1985 (Gosselink and Lee 1987).

Changes in water quality, flow, and dam passage affect the success of anadromous fish populations, including recreationally important game species. In addition to the intrinsic value of these species, the degradation of important aquatic resources has a detrimental effect on many terrestrial systems, including migratory birds and riparian forests. The importance of wildlife impacts from hydropower activities is evidenced by the provisions for wildlife habitat mitigation in the Columbia Basin under the Northwest Power Act (Brown 1988).

Recreational, Military, and Other Activities

Several other human activities can seriously affect terrestrial environments. The introduction of nonnative species into wild areas also has the potential for devastating alterations of terrestrial habitats. Even nonconsumptive human activity (e.g., recreational hiking and camping) can seriously affect natural ecosystems.

Recreational activities are the principal reason for human intrusion into natural environments. Hiking and camping have a minor but significant impact on natural forests, rangelands, and desert ecosystems. The amount of disturbance is proportional to the volume of activity and the proximity to population centers; access by roads is the determining factor. Cole (1989) has estimated vegetation loss as a result of camping, concluding that his sample campsites had absolute vegetation losses of 37 to 85%. Off-road vehicles (ORVs) can have even more severe impacts on local terrestrial habitats. In particular, ORV races can devastate fragile desert ecosystems. These environments are very slow to recover and often include rare endemic species. In addition to many rare plant species, the endangered desert tortoise is at risk. Skiing and other winter sports are examples of activities that impact relatively isolated mountain areas. These activities are often accompanied by the more deleterious effects of land use conversion into resort development.

Military maneuvers and other training or testing activities can also have significant impacts on terrestrial environments. Bird communities and certain small mammal populations were negatively affected by Army training maneuvers in the Mojave desert (Krzysik 1984). The management of military installations in the Southeast has serious implications on the survival of the endangered red-cockaded woodpecker. Both physical disturbance (especially from tracked vehicle activity) and noise contribute to habitat degradation from military activities.

Exotic species have been introduced into natural areas for game hunting, and as biological controls for other pest species. Accidental releases have also had major negative impacts on natural habitats and native species. Indeed, the entire eastern deciduous forest ecosystem has been permanently altered by the chestnut blight; the loss of tree mast likely precipitated the extinction of the common passenger pigeon. Similarly, the outbreak of dutch elm disease also contributed to the degradation of riparian habitats in the Midwest. Today, severe habitat impacts from exotic species are most prevalent in Hawaii.

The Hawaiian archipelago has lost more than 75% of its original endemic land bird fauna through prehistoric and historic extinctions; the comparable Galapagos archipelago as a whole is not known to have lost a single land bird species (Loope et al. 1988). The aboriginal Hawaiians converted most of the land below the 600-meter elevation to agriculture on the eight main islands. Subsequently introduced species and factors contributing to habitat destruction include herbivorous mammals (goats and pigs), predation by ants, frequent and intense fires, dogs, cats and mongoose, alien arthropods, mollusks, and alien plants. More than 80 vascular plant species in Hawaii currently pose threats to the native biota.

Types of Impact to Habitats

The degrees of impact caused by each of the aforementioned activities varies both within and among different kinds of activity. The level of impact is determined both by the intensity and extent of the activity, and by the specific type of impact on the habitat of concern. The impacts to habitats, and to their values and functions, from the activities discussed in the previous section fall into four general categories:

- Destruction of habitat.
- Fragmentation of habitat.
- Simplification of habitat.
- Degradation of habitat.

The nature of these impacts depends on the specific stress created by each activity. In most cases, a single activity will include several **stressor processes** that impact habitat. For example, the activity of logging a forest includes removal of the trees, associated drying of the forest floor, erosion and sedimentation of nearby streams, and disturbance from noise and human activity. The major stressor processes affecting habitats include the following:

- Vegetation removal.
- Dehydration and inundation.
- Erosion, sedimentation, and soil compaction.
- Eutrophication.
- Acidification.
- Salinization.
- Thermal warming.
- UV-B exposure.
- Contaminant toxicity.
- Noise and visual disturbance.
- Introduced species.

These stressor processes can result in the following effects on habitat:

- Direct mortality of resident species.
- Physiological stress and decreased reproduction.
- Disruption of normal behavior and activities.
- Segmentation of interbreeding populations.
- Modified species interactions and alien species invasion.

Although all of the stressors affecting habitat can have serious impacts, physical alteration of habitat has eclipsed intentional and incidental taking as the major cause of population reduction among species. At greatest risk are the following groups of species: large terrestrial mammals, bats, hole- and ground-nesting birds, amphibians, snails, conifers, herbs, grasslands, freshwater stream organisms, river fishes and mollusks, and estuarine vegetation (Norse 1990b).

Traditional impact analyses have concentrated on degradation of habitats from contamination. The focus of this analysis is on the loss and degradation of habitat through direct conversion and exploitation of the ecological resources. Although these stressors usually have a much greater impact, additional impacts from contamination should also be considered. In addition, it is important to consider the cumulative impact of multiple effects and the indirect effects of activities. The following sections discuss the different kinds of impacts on habitat.

<u>Destruction</u>

The ultimate form of habitat degradation is the destruction of a natural ecosystem through its "conversion" to another land use. In each conversion, the original natural characteristics of the land are eliminated, while the associated habitat values are modified to varying degrees. Occasionally, wildlands (providing ecosystem services and wildlife values) that have been converted to managed lands (providing harvestable timber or agricultural crops) can be restored to a similar, although not identical, natural state. In contrast, lands converted to urban or industrial uses virtually never recover their ecosystem integrity or habitat values.

Physical alterations of many kinds cause habitat destruction. In terrestrial environments, the clearing of vegetation (trees, shrubs, grasses) is the principal stressor. The greatest impacts occur when vegetation removal is accompanied by leveling operations (that destroy the original topography and soil profile) and building or road construction (covering the area with permanent structures). The burning of vegetation and the creation of landfills for waste disposal are other means of destroying terrestrial habitats. Clear-cut logging and severe overgrazing can also clear habitats of native vegetation.

In wetland environments, filling and draining operations destroy wetland habitats and create modified terrestrial habitat, while impoundments flood wetlands to create deepwater aquatic systems. As with terrestrial environments, the construction of buildings or roads can eliminate wetlands. The extraction of peat can also destroy wetlands. In aquatic environments, the inundation or diversion of water through flow alteration (via damming or channelization) is the principal means of eliminating habitat. Dredging, filling, and draining also destroy aquatic habitat.

Fragmentation

While all the activities mentioned in the previous section can result in the destruction of entire habitat types, they often only destroy part of a habitat, leaving other areas intact. Depending on the scale of concern, many instances of local habitat destruction are better thought of as habitat fragmentation. The interruption of a river with a reservoir, the clearcut logging of mature forest, and the building of a road through a salt marsh are all examples of habitat fragmentation (Norse 1990b).

Such fragmentation is the principal cause of loss of "area-sensitive" species (Harris 1985) and the most serious threat to biological diversity (Wilcox and Murphy 1985; Harris 1988). The consequences of habitat fragmentation (Harris and Atkins 1990) include the following:

- Amplification of mortality and inbreeding (i.e., risk to sedentary species from random variation in demographic and genetic variables when isolated).
- Extinction of wide-ranging species (e.g., wolves, black bears, panthers, manatees).
- Loss of interior or area-sensitive species (e.g., sharp-shinned hawk, Cooper's hawk, Swainson's warbler, red-cockaded woodpecker).
- Erosion of genetic diversity from within rare species.
- Increased abundance of weedy species (regionally distinct communities give way to globally homogeneous ones).

As an example, only 2 of 11 native large mammals in Florida (the raccoon and white-tailed deer) are doing well in the face of increasing fragmentation of natural habitats. Other examples of negative impacts from fragmentation include the spotted owl; the Spotted Owl Committee proposed that habitat conservation areas (HCAs) be linked by forests with a minimum canopy closure. Studies in Maryland, Michigan, and Oregon show that the occurrence of most forest-dependent species is correlated with forest size; contiguous forests of 100 to 300 ac are needed by area-sensitive birds, primarily long-distance, insectivorous, neotropical migrants, such as flycatchers, vireos, and wood warblers (Jahn 1991).

Simplification

Habitat simplification includes the removal of ecosystem components such as standing dead trees, cover logs, or stream debris; the death of sensitive submerged plants from siltation; and the loss of microhabitats (such as nests and dens) that are rendered unusable by human intrusion. Universally, the removal of vertical habitat structure reduces the diversity of species. Structural diversity provides more microhabitats (e.g., nest sites) and allows for more complex species interactions (e.g., avoidance of predation and partitioning of foraging space).

While forest clearcutting is both a form of destruction (for the forest stand) and of fragmentation (for the forest watershed), selective logging of preferred tree species is a form of habitat simplification. This is in contrast to timber harvesting practices that are nonselective and often closely mimic natural stand conditions. During selective cutting, not only does the composition of tree species change, but logging creates more extreme microclimates that are usually hotter, colder, drier, and windier than in natural forests. The immediate impact on resident species is the desiccation of forest plants, fungi, slugs, and salamanders that require moist conditions (Norse 1990b).

Within rangeland systems, ecosystem integrity is maintained through the balance of native grass and shrub species. Grazing by domestic livestock can selectively remove species and facilitate the invasion of exotics. In most cases, the proliferation of nonnative species results in habitat simplification that is detrimental to native birds and other wildlife.

Degradation

Degradation of habitats can include the fragmentation or simplification of habitat structure, but more specifically refers to a decrease in the health or ecological integrity of the "intact" habitat. Chemical contamination resulting from air or water pollution is a significant cause of habitat degradation. Although toxic effects may be the most severe, conventional pollutants and other effects may exist in greater frequency and extent. For example, soils are degraded through erosion or soil compaction. Lakes are particularly sensitive to eutrophication and acidification. Rivers and streams can be degraded by nutrient enrichment, as well as siltation and turbidity. Salinization and salt water intrusion also degrade habitats, as do temperature modification and noise. Underground water sources and their contributions to ecosystem integrity can be degraded by activities, such as irrigation and mineral mining, that result in the draw down of aquifers. The invasion of exotic plants and animals can seriously degrade natural systems through modified species interactions. Global climate change, including increased temperatures and UV-B exposure, has the potential to degrade habitats of all kinds.

Vulnerability to Impacts

The impacts of degrading activities on habitat depend on the vulnerability of the habitat and the relative contributions of other cumulative and interactive impacts. A habitat's sensitivity is determined by its resistance to change (i.e., its ability to resist degradation) and its resilience (i.e., its ability to recover its original condition) (Westman 1978). Resistant habitats often have intrinsically stable and fertile soils, moderate rates of water movement, mild climate regimes, and food webs that are functionally diverse and contain individuals or species preadapted to the particular stress. Resilient habitats are often topographically low and proximate to unstressed habitats containing highly mobile colonizers (Sedell et al. 1990).

Species are usually more vulnerable to anthropogenic impacts if they possess small effective population size, narrow geographic distributions, large area requirements, specialization, intolerance of disturbance, large size, slow reproductive rate, evolutionary naivete, or "amphibious" habits (Norse 1990b). Vulnerability characteristics of habitats or ecosystems (and the stressor to which they are vulnerable) are listed below:

- Impermanence (suppression of fire frequency).
- Oligotrophy (alteration of nutrient cycling).
- Undersaturation (biological invasion).
- Isolation (elimination of recolonization).
- Small size (impacts on edges).
- Proximity to human populations (disturbance).

The undersaturated naive biotas of the Hawaiian Islands and southern Florida are especially susceptible to many stressors, including invasion by exotic species. All habitat areas are vulnerable to unprecedented permanent major changes in environmental conditions. Unlike periodic natural disturbance (such as fires, windthrow, and flooding), global atmospheric change (e.g., warming and increased UV-B or CO_2) and the introduction of alien species pose challenges beyond the capabilities of most natural systems. Perhaps the greatest threat to biodiversity is the impending interaction between climate change and habitat fragmentation.

General Mitigation Procedures

Appropriate measures for the mitigation of habitat loss or degradation depend on both the habitat type and the specific degrading activities, stressor processes, and habitat impacts. Specific mitigation information is provided in the regional sections of this document. In this section, general considerations for habitat mitigation are discussed. For a mitigation to be successful, the ecological integrity of the habitat must be maintained. This can be accomplished directly by preservation measures that avoid impacts. In other cases, careful mitigation plans can reduce or eliminate impacts on the integrity of the habitat.

<u>Habitat Integrity</u>

Traditionally, mitigations have concentrated on species-specific habitat components such as the availability and appropriate interspersion of cover, food, and water. Other species requirements include protein-rich foods, den or nest sites, and territorial spacing or colonial clustering, and may vary seasonally, especially among migratory waterfowl and anadromous fish. Greatest attention has been paid to the diversity of habitat structure, both vertical layering and horizontal edge or transition zones, that provide for greater species and ecological diversity. While these considerations are appropriate for mitigations focusing on certain species or individual site diversity, they do not incorporate landscape-level concerns for regional diversity. For the purposes of this document, mitigations of habitat degradation will focus on the ecological integrity of the habitat of concern and not on the species or diversity components that may be desirable from a wildlife management point of view.

Recent research has indicated that floristic (plant species) diversity is superior to structural (number of vegetation layers and patches) diversity as an indicator of wildlife distribution. This emphasizes the need to avoid oversimplification in habitat analyses and to look at the detailed ecology of each habitat and define it in precise ecological terms. Natural habitats are dynamic ecological systems that require natural patterns of disturbances. Proper mitigation plans must provide for natural habitat heterogeneity in time and space. An important tool for providing natural disturbance patterns is fire management. Proper use of controlled fires can be an effective mitigation of the impact of fire suppression in managed areas.

Mitigation for habitat conservation must ensure that the cumulative impacts of all activities within the landscape (perhaps over areas of 10,000 to several 100,000 ac) are addressed to maintain ecosystem integrity and health. The preservation of individual habitat areas is often not sufficient to maintain the ecological integrity of the greater ecosystem. In addition, the size, diversity, and distribution of key habitat tracts must be conserved to provide for the natural diversity characteristic of the larger eco-complex or region. Finally, unique ecosystems (such as islands) may require unique mitigation solutions (Samson et al. 1991).

<u>Mitigation Guidance</u>

Mitigations to address the habitat impacts of destruction, fragmentation, simplification, and degradation include the following four measures (modified from Flather and Hoekstra 1989):

1. Preservation
   - Outright purchase or set aside of land
   - Partial purchase through conservation easements, long-term leases, or management agreements.

2. Management practices
   - Rotation and method of timber harvesting
   - Timing and extent of grazing
   - Control of pollution
   - Elimination of structures.

3. Restoration
   - Direct manipulation through seedings, plantings, physical or chemical treatment
   - Creation of wetlands
   - Control of pollution
   - Removal of barriers to fish migration
   - Control of livestock access to riparian areas.

4. Compensation
   - Purchase of lands of comparable habitat size and quality
   - Provision of financial restitution.

A more detailed set of Mitigation Means and Measures (in general priority order) has been devised by the Fish and Wildlife Service for mitigation development related to fish and wildlife and their habitats (FR 46(15):7660, 1981). This list is provided in the accompanying box.

U.S. Fish and Wildlife Service
Mitigation Means and Measures

A. Avoid impact
1. design project to avoid damage or loss including management practices such as
   - timing of activities or
   - structural features such as multiple outlets, passage or avoidance structures, and water pollution control facilities
2. use nonstructural alternative
3. cancel project

B. Minimize impact
1. include conservation of fish and wildlife as authorized purpose
2. locate a least environmentally damaging site
3. reduce the size of the project
4. schedule timing and control of construction and maintenance to minimize disruption of biological community structure and function
5. use selective tree clearing or other habitat manipulation
6. control water pollution through BMPs
7. time and control flow diversions and releases
8. maintain public access
9. control public access for recreational or commercial purposes
10. control domestic livestock use.

C. Rectify the impact
1. regrade disturbed areas to contours for optimal habitat or original condition
2. seed, fertilize, and treat areas to restore fish and wildlife
3. plant shrubs and trees and other vegetation to speed recovery
4. control pollution spoil areas
5. restock fish and wildlife in repaired areas

D. Reduce or eliminate the impact over time
1. periodically monitor to ensure continuous operation of mitigation
2. train personnel properly to preserve fish and wildlife
3. maintain or replace equipment or structures to prevent loss due to equipment/structure failure

E. Compensate for impacts
1. conduct wildlife management activities to increase habitat values; give priority to project lands and nearby public lands
2. construct habitat to fully restore and rehabilitate altered habitat, or to modify existing habitat suited "evaluation species" to completely offset habitat value losses
3. designate fish propagation facilities
4. designate legislative set-aside or protective designation for public lands
5. designate buffer zones
6. lease habitat
7. acquire wildlife easements
8. acquire water rights
9. acquire land in fee title

Mitigation Principles

The development of specific mitigation plans must be based on a thorough understanding of the site conditions and the activities impacting habitats. Nonetheless, certain basic principles of ecological management should be followed when specific mitigation measures are developed. The following seven general mitigation principles apply to all habitat conservation efforts:

1. Base mitigation goals and objectives on a landscape-scale analysis that considers the needs of the region.

2. Mimic natural processes and promote native species.

3. Protect rare and ecologically important species and communities.

4. Minimize fragmentation of habitat and promote connectivity of natural areas.

5. Maintain structural diversity of habitats and, where appropriate, species diversity to promote the natural variety of the area.

6. Tailor management to site-specific environmental conditions and to the unique impacts of the specific degrading activity.

7. Monitor for habitat impacts from activities and revise mitigation plans as necessary.

A landscape or ecosystem-level perspective is central to these principles. R. Max Peterson (Emeritus Chief of the Forest Service and Executive Vice President of the International Association of Fish and Wildlife Agencies) stated that "when land is cleared, care must be taken to maintain the minimum size areas of sensitive habitats, with buffers and corridors as needed to ensure the integrity of the landscape ecosystem" (Giltmier 1991). The concept of providing for landscape integrity when habitats are fragmented is central to habitat mitigation in forest, rangeland, wetland, and aquatic systems. The two most important methods for maintaining the integrity of fragmented habitats are (1) the provision of buffer areas, and (2) the creation of habitat corridors. Buffers represent the principal method of avoiding impacts to sensitive areas, and habitat corridors provide the best means of mitigating habitat isolation. The most common means of creating both buffer areas and corridors is the preservation of natural habitat along streams, steep slopes, and other sensitive areas.

Habitat Buffers

The preservation of a habitat of concern includes both the avoidance of direct conversion of the area and the maintenance of adequate buffer areas so that edge effects and other negative impacts do not affect the sites. For example, powerline corridors through forests can be "feathered" to avoid some edge effects (Gates 1991). Additional areas adjacent to the corridor can be cut to create successional bands of vegetation parallel to the corridor opening; this reduces predation rates at the edge and minimizes the barrier effects. However, a wider edge results in less forest interior.

Mitigation procedures for many projects can be designed to reduce the effective width of a cleared area and thus decrease the barrier effect. These include creation of small lobes or peninsulas of dense vegetation reaching into the open area, or the creation of entire breaches across the area, either by leaving the habitat intact or by staggered defoliation regimes. The establishment of a stable shrub community in a forest corridor can provide movement by less mobile animals with small home ranges (Niering and Goodwin 1974).

Research into the impacts on benthic invertebrate communities of streams indicates that buffer strips of at least 30 m are required to prevent alteration in invertebrate diversity and ecological structure (principally the increase in abundance of pollution-tolerant taxa such as chironomids). These buffer strips serve to maintain riparian canopy and stream channel stabilization. Failed road crossings also negatively impact stream ecosystems (Erman et al. 1977).

Habitat Corridors

Mitigation of habitat fragmentation involves the restoration of habitat "connectivity" (Norse 1990b). To address the effects of fragmentation, conservation biologists are calling for increased provision of habitat corridors. Unlike untested management plans based on island biogeography theory, corridors have been used successfully in wildlife management for 50 years (Harris and Atkins 1990). Corridors provide for the movement of animals, serve as a population source, contain whole communities, and withstand natural disturbance events, but they also provide for contamination transmission (Csuti 1991). Because edge effects reach 200 to 600 m into the forest, Pace (1990) recommends a minimum corridor width of 6.4 km to mitigate edge effects.

In a landmark court decision concerning the USDA Forest Service timber sales in the Klamath National Forest, federal agencies were required to consider an area's importance as a "biological corridor" linking wilderness areas before permitting logging. The resultant Klamath Corridors Proposal can serve as a model of habitat fragmentation mitigation (Pace 1990). It recommends connectivity as superior to isolation, continuity over fragmentation, and creation of larger rather than smaller corridors.

Mitigation Measures

The first priority in developing mitigation plans for habitat loss or degradation should be avoidance of the impact. This is usually a siting issue, where construction operations and degrading activities are located at a distance from the habitats of concern. The habitat is adequately preserved if all possible impact scenarios are accounted for. Barring this solution, effective management measures must be implemented to ensure the protection of the habitats of concern. Failing effective management, mitigation falls to the restoration of habitat, which is often problematic, or finally to compensation.

Restoration activities will not be discussed in this document, although they are receiving increased attention as mitigation measures, especially in wetland and aquatic systems. The recent volume produced by the National Research Council (1992) provides a comprehensive discussion of the science, technology, and public policy involved. Many of the principles espoused in this book also apply to terrestrial systems.

This document focuses on the general management practices that can be undertaken to mitigate habitat degradation and loss resulting from activities in forest and rangeland environments. A central tenet of the management approach to habitat mitigation is the control of pollution. This is especially true for wetland and aquatic systems where, after physical alteration, off-site impacts to hydrology and water quality pose the greatest threat. There is also a growing body of literature on best management practices

(BMPs) as mitigation measures for aquatic systems. Notably the nonpoint source, clean lakes, and national estuary programs of EPA are promoting BMPs to protect sensitive habitats. Many of these measures apply to wetlands and are being implemented under section 404 of the Clean Water Act and provisions of the Coastal Zone Management Act. The reader should refer to these programs for additional information on mitigating impacts to wetland and aquatic systems.

In contrast to aquatic systems, forests and rangelands are primarily threatened by direct exploitation of their resources (trees and forage grasses). Specific guidance on mitigation measures is provided in each regional habitat evaluation section. The following discussion addresses general mitigation issues for timber harvesting and grazing methods.

<u>Timber Harvesting Mitigation Methods</u>

At a minimum, the production of commercial wood products from an area must not exceed the sustainable level if the ecological integrity of a forested area is to be maintained. Where sensitive forest types exist, logging may be completely prohibited or constrained to specific methods to prevent habitat loss or degradation. In other areas, more extreme harvesting methods may be allowed or prescribed to establish or maintain desired forest conditions. Acceptable methods will vary according to local forest ecology and the desired future condition of the site. Analysis of harvesting techniques must be based upon an analysis of the structure and diversity of the forest canopy, midstory, and understory.

A recent directive of the Chief of the U.S. Forest Service acknowledges this fact and points out that clear cutting is acceptable only when needed to replicate natural ecological processes. Selective cutting can preserve forest structural diversity, the primary determinant of wildlife habitat (Harris et al. 1979). However, it can reduce horizontal diversity (NRC 1982). The harvesting technique employed must be based upon sound silvicultural prescriptions and demonstrate its capability to maintain vertical diversity (foliage height diversity), horizontal diversity (interspersion, edge, juxtaposition, patchiness), and a mixture of live and dead wood. Specific timber harvesting operations should be designed to preserve the structure and diversity of the natural forest habitat.

<u>Grazing Mitigation Methods</u>

The current degraded state of rangelands requires restoration as well as management plans. In both cases, the timing and extent of continued grazing will determine whether range conditions worsen or improve. Increased irrigation for agriculture may delay improvements by adversely affecting water tables and stream flow on rangelands. Rest-rotation grazing can improve range conditions, while intensified chemical use and mechanical brush removal will likely further degrade range habitats. The future management of riparian areas will have the greatest impact on rangeland wildlife and ecosystem health (NRC 1982).

In the past, range condition has been estimated by forage production or production of livestock. More recently, condition has been based on the deviation from an ideal range condition or ecological climax. More effective use of ecological analyses of range condition will improve the management of rangelands. In particular, range managers need the following tools (Wald and Alberswerth 1989):

- More data (range condition is unknown on many rangelands).

- Management plans for each site (these should be ecologically based and site specific).
- More management resources.
- Commitment from management to implement grazing reductions or riparian habitat improvement.

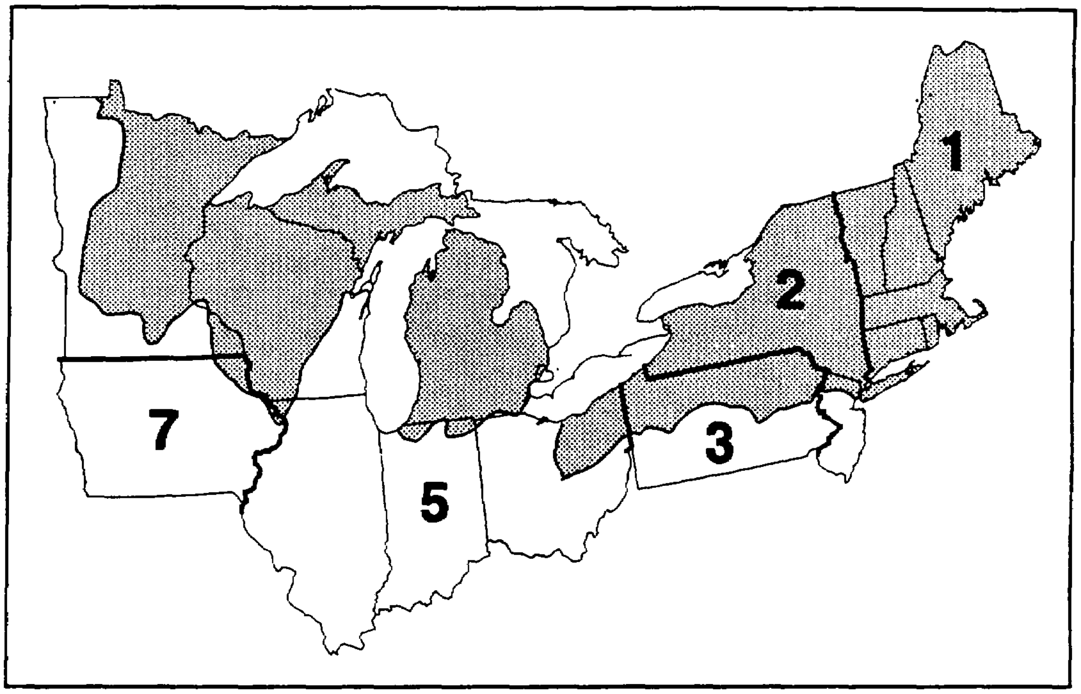
Monitoring for Mitigation Compliance

Successful mitigation of habitat impacts requires that the proposed mitigation measures are effectively implemented and maintained. However, the consideration of habitat effects is often hampered by information gaps and limits to predictive capability. Therefore, it is essential that all mitigation plans include adequate provisions for baseline and post-project monitoring of habitat conditions.

The fact that many restoration projects designated as mitigation have not achieved their desired objectives is well documented. It is also believed that mitigation measures for many projects are not adequately implemented or enforced. Therefore, determination of the true effectiveness of mitigation should be the goal of monitoring programs. The following ten-step process for monitoring mitigations for habitat impacts has been modified from Noss (1990):

- Establish objectives of the mitigation.
- Gather and integrate data.
- Establish baseline conditions.
- Identify elements at risk.
- Formulate specific questions to be addressed by monitoring.
- Select indicators.
- Identify control areas and treatments.
- Design and implement the sampling scheme.
- Validate relationships between indicators and endpoints.
- Analyze trends and recommended management actions.

North Habitat Region: *Northern Lakes and Forests*



Geographical Description of the Region

The North Habitat Region, *Northern Lakes and Forests*, contains all of eight states and parts of eight additional states. The region includes all of Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, Michigan, and parts of New Jersey, Pennsylvania, Ohio, Iowa, Indiana, Illinois, Wisconsin, and Minnesota. EPA Region 1 is included in its entirety; parts of EPA Regions 2, 3, 5, and 7 are also included. The accompanying map indicates the boundaries of this habitat region and the states it comprises.

The *Northern Lakes and Forests* comprises eight ecoregions (Omernik 1987). The vegetation of this region includes northern hardwoods (maple, birch, beech, hemlock), elm, ash, Great Lakes spruce and fir, Great Lakes pine, conifer bogs (spruce, larch, arborvitae), maple, basswood, and oak savanna (oak and bluestem). The land use patterns include swamps, marshlands, forests and woodlands (mostly ungrazed), croplands, croplands with pastures, and urban.

Habitats of Concern

The *Northern Lakes and Forests* contains many habitats of concern, of which the most obvious fall into the three general categories of old-growth forest, barrens, and Great Lakes ecosystems. The principal habitats of concern most at risk in the *Northern Lakes and Forests* are listed below.

PRINCIPAL HABITATS OF CONCERN
IN THE *NORTHERN LAKES AND FORESTS*

1. Old-growth and mature forests
   - northeast conifer and hardwoods forests
   - central hardwoods forests
   - boreal forests of northern lake states

2. Barrens
   - pitch pine-scrub oak barrens
   - Appalachian shale barrens
   - other cliff and ridge talus, tundra, meadow, and heath communities

3. Great Lakes coastal habitats
   - barrier islands
   - dune systems
   - coastal wetlands
   - pannes or intradunal ponds
   - rocky shores along Lake Superior with arctic species
   - bluffs with oak savannas, jack pine woodlands, and beech-maple forests

Habitat Values and Trends

The *Northern Lakes and Forests* originally consisted of a vast forested area covering both New England and the northern Lake States. Once virgin forest, New England was cultivated on 75% of arable land by 1840, but is now primarily forested again (DeGraaf 1991). The White Mountains of New Hampshire and western Maine contain many forest cover types; northern hardwoods constitute approximately half of the area. Because of the glacial origin of soils in New England, many of the most fertile sites are on midslope and produce hardwood forests. The impervious layer (fragipan) underlying much of these till soils produces vernal pools, seeps, and wet ground during the spring even on upper slopes. Therefore, the forest landscape of New England is a mosaic of forest types and nonforest habitats that occur in relatively small patches, especially in the mountains. Among these isolated habitats are various forms of barrens that support numerous rare species. The vegetation of the northern lakes region has a more recent history of timber harvesting and forest regrowth, but consists of a greater variety of habitats including many northern forest types, coastal habitats, and wetland types.

Northeastern Forests

Forests of seven northeastern states comprise 49.5 million ac or about 70% of the total regional land area (Barrett 1980). Major forest type groups are maple-birch-beech, white-red jack pine, spruce-fir, loblolly-shortleaf pine, and oak-hickory. By 1890, most of the northern spruce had been cut; the hardwood forests soon followed. Large fires swept over northern New England shortly after the turn of the century. Other forest losses have been due to the chestnut blight, diseases of birch and beech, and gypsy moth attacks on oak. Overcutting of commercially desirable species has resulted in the expansion of elm-ash-red maple at the expense of beech-birch-sugar maple. In the Northeast, substantial areal declines have occurred in oak-gum-cypress (53%), loblolly-shortleaf pine (49%), elm-ash-cottonwood (38%), aspen-birch (25%), oak-hickory (20%), and spruce-fir (14%) (Flather and Hoekstra 1989).

In the last 100 years, one-fifth of the region's total acreage has reverted from pasture and tillage to brush and forest (Hagenstein 1990). Since the 1950s, most of the increase in forest area is directly linked to the decrease in farm area, especially dairy farming. By the 1960s, the areal extent of suburban developed land surpassed that of agricultural land. Since that time, the development of recreational homes in the mountains and along coasts and lakeshores has resulted in large areas of fragmented, sensitive lands. This process has fragmented ownership in a region with the lowest ratio of publicly owned land of any forested region in the United States. The result of this long history of exploitation is that less than 1% of New England's total acreage is in pristine ecosystems (Giltmier 1991).

Extended wildfire protection and insect and disease control programs have greatly reduced the loss of forest trees to these factors. However, both mortality and lowered growth rates have resulted from air pollution in the Appalachians and eastern Canada. Projections indicate a decline throughout the North over the next 50 years. Urban area has doubled, and small forest parcels and low-value timber lands will likely be converted to other uses. However, several states in the North have adopted regulations to ensure the regeneration of logged areas and to protect water quality (Hagenstein 1990).

Northern Lakes Forests

Approximately 43% (52 million ac) of the total area of Michigan, Minnesota, and Wisconsin is forested (Barrett 1980). Replacement of forest with agriculture increases from the East to the West and from the North to the South. The Lake States forests are 75% hardwoods (principally aspen-birch) and 25% conifer (mostly spruce-fir). They include 15 northern forest cover types, 4 central hardwood cover types in the "big woods" area of Minnesota and the southern portions of Wisconsin and Michigan, and 8 boreal forest cover types.

In 1902, the region led the country in timber production; by 1910, the majority of commercially valuable white and red pine was gone. In later years, overexpansion of farming cleared vast areas of forest. Fires and swamp drainage also contributed to devastation of the forest area in the region. Substantial losses are still occurring in the forested areas in the northern Lake States. Logging is proceeding at a rapid rate in Michigan. In Wisconsin, oak forests are being intensively harvested for oak veneer, and aspens are declining as a result of forestry management practices. White pine and hemlock in southern Michigan, once dominant in the area, are today nearly absent. The elm-ash forest type in

Ohio, Indiana, and Michigan has been reduced by 90% as a result of conversion to agriculture and urbanization.

Forest Values

Forest ecosystems support 90% of the total bird, amphibian, and fish species and 80% of mammal and reptile species in the United States. In addition, the *Northern Lakes and Forests* contains an average 2.6 endangered and threatened species per county as of 1984 (Flather and Hoekstra 1989). Some of the ecological values of each of the regional forest types are listed below:

- Oak-hickory - supports southern bald eagle, red wolf, red-cockaded woodpecker and contains many diverse mesic environments.
- Maple-beech-birch - includes a wide variety of tree, shrub, and forb species that provide aesthetic, wildlife (e.g., moose), and recreational resources.
- Spruce-fir - contains many remote and pristine environments that support moose, great horned owl.
- Aspen-birch - represents a pioneer community that follows disturbance and supports ruffed grouse and moose.
- White-red-jack pine - supports threatened species such as eastern timber wolf, peregrine falcon, and Kirtland's warbler.
- Elm-ash-cottonwood - represents important riparian habitat along moist river and stream bottoms, and in and around swamps and depressions.

Old-Growth and Mature Forests

Old-growth forests are unique, vanishing environments that merit preservation for aesthetic, ecological, and scientific values (Society of American Foresters 1984). Although the *Northern Lakes and Forests* do not contain the acreages of virgin forest still found in other parts of the country, many mature forests greater than 100 years old do exist. These mature forests possess a variety of important ecosystem values and should be the focus of habitat conservation efforts.

As an example, the majority of remaining old-growth stands in Pennsylvania are on steep mountain slopes and deep, narrow, boulder-strewn ravines. This is a result of a long history of natural disturbance and anthropogenic degradation that has dramatically changed the composition of the present day oak forests of Pennsylvania. They differ dramatically from the original types that were present before settlement in early 1600s. Even with extensive clearing for agriculture and coal mining, the state was 75% forested in early 1800s. By 1850, however, Pennsylvania was the logging center of nation. Subsequent attacks by the American chestnut blight and beech bark fungus and severe vegetation destruction from growing white-tailed deer populations killed many trees. Most important, extensive clearcutting caused a shift in species composition with declines in white pine and eastern hemlock and increases in yellow birch, black cherry, and red maple. Remaining old growth in Pennsylvania can be classified into four types after Kuchler (1964): beech-maple; hemlock-northern hardwood forest (hemlock-white pine-beech-black birch); Appalachian oak forest (chestnut oak-white oak-red oak-hickory); and mixed mesophytic forest (white oak-red oak-yellow poplar-basswood) (Smith 1989).

The old-growth forests of the northern Lake States are another important habitat type. Historically, pine and hemlock-northern hardwood forests were most extensive. Nontraditional old-growth ecosystems include northern white-cedar, speckled alder, northern pin oak, black ash, bigtooth aspen, and trembling aspen. The old-growth forest ecosystems of this region contain a greater regional and local diversity than has been generally appreciated (Barnes 1989). *Northern Lakes and Forests* habitats vary with the pattern of structurally (physiography, soil, vegetation) and functionally different landscape ecosystems.

<u>Great Lakes Coastal Ecosystems</u>

The many wetland and sand dune ecosystems of the Great Lakes coastal region are important in the *Northern Lakes and Forests* and vary according to physiography, associated soils, and other abiotic factors (Barnes 1989). Many of the ecosystems that have not been destroyed or highly modified are imminently threatened. Impacts include the lumbering of most Great Lakes forests in the late 1800s, destruction of over half of the wetlands, pollution from heavy industry, and the proliferation of lakefront residences and structural modifications to protect shoreline property. Degradation from recreational use and the accidental or purposeful introduction of alien species are also important (Hiebert 1990).

<u>Wetlands and Aquatic Systems</u>

Because the Great Lakes contains 54% of the nation's water area (a total of 58 million ac), wetlands and aquatic systems are especially important habitats in the *Northern Lakes and Forests*. Along the Great Lakes, large inland coastal marshes lie behind beach ridges and are often influenced by lake water levels and wind tides. Other wetlands are eutrophic or boglike and, although still common, are much reduced in size (e.g., 71% of Michigan marshes have decreased in area). In addition, many glacial wetlands occur within the northern forests. They are often surrounded and invaded by trees producing boglike edges with sedges and mosses and alder willow.

Many smaller lakes exist throughout the *Northern Lakes and Forests*. Acidification from atmospheric deposition has had a severe impact on lakes of the Northeast. Diverse marine environments exist along the northern Atlantic coast, including many glaciated estuaries and the modified Hudson River Valley.

Activities and Impacts Affecting Habitats

The major sources impacting habitats in the *Northern Lakes and Forests* include residential developments, industrial and commercial developments, dam construction, interstate highway or expressway construction, logging and silvicultural practices, solid waste disposal, and peat mining. These activities have had adverse impacts on species populations and their behavior, as well as on ecosystem processes such as energy flow and nutrient cycling. They have also contributed to the proliferation of nuisance plants and animals. In its comparative risk analysis, EPA Region 1 concluded that the highest risk to upland and aquatic habitats in New England is concentrated in rapidly growing areas (e.g., central Connecticut, southern Maine, and New Hampshire). Historical losses of terrestrial environments are greater toward the coast and the southern part of the region.

Agricultural conversion and grazing are relatively minor activities in the region, while timber harvesting practices and peat mining continue to degrade terrestrial environments throughout the region, especially in Maine and the northern Lake States. However, the conversion of land to industri... residential (including second homes), and transportation uses is the most severe cause of terrestrial habitat loss in the *Northern Lakes and Forests*. The major metropolitan areas in this region are under enormous pressure from human populations, and the effects are degrading the remaining natural habitats in the area.

The following activities result in the major impacts on habitats of concern in the *Northern Lakes and Forests*.

IMPACTS ON HABITATS OF CONCERN IN THE *NORTHERN LAKES AND FORESTS*					
	Land Conversion	Timber Harvesting	Grazing	Water Management	Other
Mature forest	Destruction from residential development	Simplification by replacement with plantation species	Minor	Minor	Degradation with increased recreation pressure
Barrens	Destruction from residential development	Degradation	Degradation	Minor	Degradation with increased recreation pressure
Great Lakes systems	Destruction from residential development	Moderate	Minor	Destruction of wetlands	Degradation with increased recreation pressure

Land Conversion

Historically, land conversion of both uplands and wetlands has profoundly affected the natural communities in the Northeast. The early clearing of eastern forest for small farms benefitted robins, woodchucks, and bobwhite quail, but negatively impacted wild turkeys, black bears, and moose. Since that time, the large population centers are primarily responsible for the conversion of natural areas, i.e., through industrial and residential development. Because cities concentrate on coastal areas, the unique environments of the Atlantic and Great Lakes shores have been most affected. Recent increases in second home and resort development are now contributing to construction in previously pristine areas. In many cases, rare barrens, dunes, and wetlands areas are being converted with the loss of many rare plant species. More generally, "spin-off development" associated with highway construction has facilitated the expansion of land use conversions into rural areas. This increased road construction is causing severe fragmentation of terrestrial habitats.

Timber Harvesting

Timber harvesting activities can fragment, simplify, and degrade forest habitats. The faunal communities inhabiting forests vary with the successional, or seral, stage such as grass/forb, shrub/seedling/sapling, medium tree, and large tree. Because the principal impact of timber harvesting practices is to convert forest stands from later to earlier seral stages, logging has a major impact on resident animal as well as plant species. Timber harvesting telescopes plant succession, shortens rotations, compresses seral stages; and decreases the proportion of old growth. For example, old-growth spruce, fir, and white cedar disappear with short rotations in Maine (i.e., reducing wintering grounds for deer). The conversion of hardwoods to conifers creates structurally simplified plantations that reduce structural diversity and wildlife. This has produced a trend away from declining habitat types and toward common habitat types. Management for monotypic even-aged stands causes increases in forest pest damage which often result in large-scale spraying and the accompanying impacts. Timber harvesting activities also impact nearby aquatic systems through erosion and sediment transport.

Second in concern to the decrease in old-growth forests is the general decline in neotropical migrants that breed in eastern hardwood forests. Although the situation is complicated by losses of wintering habitats for long-distance migrants in Latin America, results indicate that species still present in large blocks of forest are absent from small patches (Robbins et al. 1989). Fragmentation of forest habitat from timber harvesting and from land conversions, especially for transportation, appears to be the major cause of these declines (Terborgh 1989).

Recreational Activities

Forest habitats, and especially the many unique barrens, dunes, and wetland habitats in the *Northern Lakes and Forests,* can be negatively impacted by recreational activities. These impacts are usually localized, but can severely affect the hydrology and nutrient cycling regimes of vulnerable habitats. As an example, the annual Canaan Valley motorcross contributes to the degradation of sensitive wetland habitats through soil erosion.

Mitigations of Impacts

The conservation of habitats requires consideration of mitigations for the major activities impacting habitats of concern. In the *Northern Lakes and Forests*, the primary habitat impacts are caused by the following:

- Land conversion and timber harvesting of old growth and mature forests.
- Land conversion of barrens and other rare habitat types.
- Land conversion and pollution of Great Lakes ecosystems.

Land Conversion

Effective mitigation of land use conversion activities can sometimes be obtained only by avoiding impacts on rare or unusual habitat types. Rarely, if ever, is restoration or compensation an adequate mitigation for the loss of these habitats. In these cases, mitigation is a siting issue, where construction and degrading activities are located a distance from the habitats of concern. The habitat is adequately preserved if all possible impact scenarios are accounted for. Barring this solution, effective management measures must be implemented to ensure protection of the habitats of concern.

In the case of barrens habitats or unique Great Lakes ecosystems, hydrological and contamination concerns are especially important. Construction or resource management activities require the use of sediment filter strips and other means of intercepting off-site contaminants. Road building and structural "improvements" must not result in altered hydrological regimes. Where rare plant types exist or where habitats are unstable (e.g., sand dunes), recreational access associated with nearby development may have to be limited.

Amelioration of impacts from land conversion to transportation uses requires special mitigation measures. As with all land conversion, the construction of highways and power-line corridors is primarily a siting issue. Avoidance of sensitive habitats may be accomplished by modifications to the route design, and the extent of disturbance can be limited by careful construction practices. However, fragmentation of the larger area is unavoidable in the case of land conversion to transportation corridors. Structural mitigations can be used to lessen the impact on animal movement across transportation routes. Primarily, these include the construction of fences and underpasses. The goal of these structural measures should be to mimic the natural movement and migration patterns of the affected species.

Timber Harvesting

At a minimum, the production of commercial wood products from an area must not exceed the sustainable level if the ecological integrity of a forested area is to be maintained. Where sensitive forest types exist, logging may be completely prohibited or constrained to specific methods to prevent habitat loss or degradation. In other areas, more extreme harvesting methods may be allowed or prescribed to establish or maintain desired forest conditions. Acceptable methods will vary according to local forest ecology and the desired future condition of the site. Analysis of harvesting techniques must be based upon an analysis of the structure and diversity of the forest canopy, midstory, and understory.

A recent directive of the Chief of the U.S. Forest Service acknowledges this fact and points out that clear cutting is acceptable only when needed to replicate natural ecological processes. Although, selective cutting can preserve forest structural diversity, it can reduce horizontal diversity (NRC 1982). The harvesting technique employed must be based upon sound silvicultural prescriptions and demonstrate its capability to maintain vertical diversity (foliage height diversity), horizontal diversity (interspersion, edge, juxtaposition, patchiness), and a mixture of live and dead wood. Specific timber harvesting operations should be designed to preserve the structure and diversity of the natural forest habitat.

An important component of selective cutting should be the preservation of standing dead trees. Northern hardwood forests contain 24 species of birds that nest, roost, or forage for invertebrates in standing trees with decayed wood. These cull trees are usually the first focus of forest-thinning operations, to the detriment of the birds. Breeding bird abundance declines rapidly following a clear cut, and the species composition continues to change for 10 to 15 years (DeGraaf 1991). However, if trees with cavities are saved, many of these species can successfully forage on sound boles. About one large cavity or den tree per 2 ha is required for populations of large species such as wood ducks; this requires harvest rotations of 100 to 125 years (although rotations of 65 years produce trees large enough for species nesting in smaller cavities).

Responding to the "biodiversity crisis," the U.S. Forest Service is moving toward an ecosystem approach to forest management (Bob Szaro, personal communication). Recent forest management plans have incorporated tenets of the "New Forestry" espoused by Jerry Franklin. These progressive plans require the rigorous implementation of ecological management practices to maintain forest productivity and to preserve the functioning of sensitive forest components such as old-growth or late-successional forests. Effective mitigations for habitat conservation in forest management require specific management measures at the site, watershed, and landscape levels. For example, the location and size of timber harvests should be planned to minimize reduction of the core area of mature forest (e.g., harvest only alternate basins until regrowth). Maintenance of mature-forest stands in managed landscape can be achieved by extending rotation (beyond 80) to 150 to 200 years, by leaving some stands unharvested for old growth, and by linking stands. Landscape-scale considerations include the provision of buffer zones and habitat corridors as discussed in the introduction of this document. The following management measures are recommended for conserving habitat within managed forests:

- *Minimize the construction of new roads and close roads not in use either permanently or* seasonally.
- Use best management practices (BMPs), such as filter strips, to minimize erosion during harvesting or road construction.
- Maintain 100-ft riparian zones with adjacent feathered transition zones to buffer edge effects.
- Restrict harvesting operations to periods when the ground is either dry or frozen.
- Maintain site productivity by retaining large woody material and minimizing mineral soil exposure and compaction during harvesting.
- Manage for natural disturbance patterns to maintain natural openings and successional-stage composition.
- Maintain connections between blocks of interior forest, especially old growth.
- Provide for the protection of special areas, including cliffs, caves, taluses, riparian areas, and old-growth stands.
- Maintain the structural integrity and the native variety of the forest by managing for the natural composition of the following components: vegetative types, seral stages, tree types and sizes, standing dead trees and down material, tree snags, and cavity trees.

Guidelines for Reviewers

Reviewers of environmental impact assessments will find this document useful if they follow the steps laid out in the introduction:

1. Review the status and trends of habitats in the region.

2. Identify the habitats of concern.

3. Link the activities involved with impacts to these habitats of concern.

4. Devise appropriate mitigations for the impacts.

Each reviewer can then determine the adequacy of the environmental impact assessment in question and recommend modifications to enhance its effectiveness.

In identifying the habitats of concern, the reviewer should supplement the information in this document with detailed locational information on the abundance and distribution of habitats within the region of interest, and with any historical information on the extent and quality of these habitats. Most important, the reviewer should characterize the habitats in terms of their ecological values (e.g., use of wooded wetlands by migratory waterfowl).

In considering the links between activities and habitats, the reviewer should look beyond direct impacts to indirect and subtle effects, including cumulative impacts, interactive and synergistic impacts, and scale-dependent impacts (e.g., effects of fragmentation on ecosystem integrity and species home ranges).

In devising possible mitigations, the reviewer should follow the seven principles for habitat mitigation repeated below. The reviewer also should determine whether adequate assurances have been given that the mitigations proposed will be completed.

1. Base mitigation goals and objectives on a landscape-scale analysis that considers the needs of the region.

2. Mimic natural processes and promote native species.

3. Protect rare and ecologically important species and communities.

4. Minimize fragmentation of habitat and promote connectivity of natural areas.

5. Maintain structural diversity of habitats and, where appropriate, species diversity to promote the natural variety of the area.

6. Tailor management to site-specific environmental conditions and to the unique impacts of the specific degrading activity.

7. Monitor for habitat impacts and revise mitigation plans as necessary.

Finally, the reviewer should consider the proposed activities and mitigations in the context of relevant regional program goals and objectives (e.g., whether the outcome of the project will be in accordance with principles set out by regional planning commissions such as those established for the New York Bight and the Great Lakes).

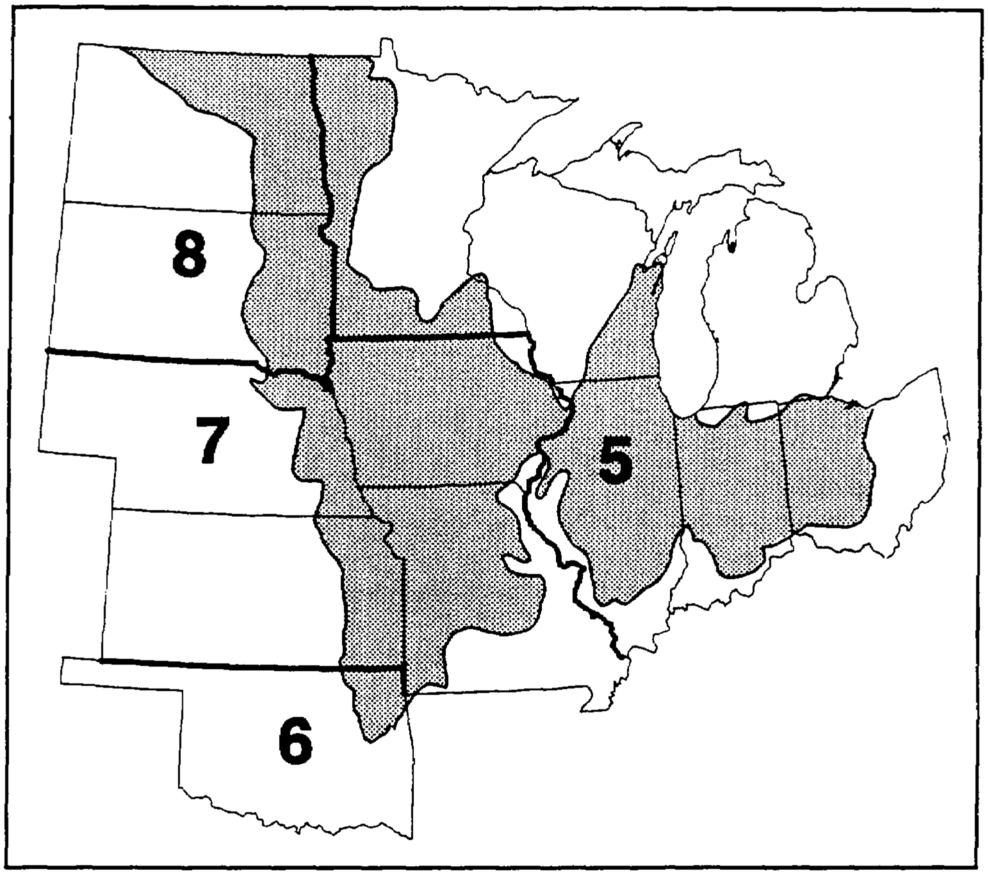
Contacts and Information Sources

When considering habitat conservation issues in an environmental impact assessment for the *Northern Lakes and Forests*, the reviewer should consult the following organizations and individuals for information on habitat impacts and mitigations:

State Natural Heritage Programs
U.S. Fish and Wildlife Service, Regional and Area Offices
State Fish and Game Departments
University and Research Programs
Herbaria and Museums

Lesley Sneddon, Regional Ecologist, The Nature Conservancy
Ralph Pisapia, Associate Director, Fish and Wildlife Enhancement, U.S. Fish and Wildlife Service

Midwest Habitat Region: *Midwest Croplands*



Geographical Description of the Region

The Habitat Region, *Midwest Croplands*, contains parts of 13 states. The region includes parts of Ohio, Indiana, Illinois, Missouri, Iowa, Wisconsin, Minnesota, North Dakota, South Dakota, Iowa, Nebraska, Kansas, and Oklahoma. Parts of EPA Regions 5, 6, 7, and 8 are included. The accompanying map indicates the boundaries of this habitat region and the states it comprises.

The *Midwest Croplands* comprise eight ecoregions (Omernik 1987). The vegetation of the *Midwest Croplands* includes a range of mosaic of bluestem, prairie (bluestem and indiangrass), oak, hickory, wheatgrass, needlestem, oak savanna, maple, basswood, beech, elm, and ash. The land use patterns are croplands and croplands with grazing lands.

Habitats of Concern

The *Midwest Croplands* contains many habitats of concern; the most obvious fall into the four general categories of oak savannas, native prairie remnants, wetlands, and old-growth central hardwood forest. The principal habitats of concern most at risk in the *Midwest Croplands* are listed below.

PRINCIPAL HABITATS OF CONCERN IN THE *MIDWEST CROPLANDS*

1. Oak savannas

2. Native prairie remnants
   - tallgrass
   - little bluestem prairie
   - hill prairie

3. Wetlands
   - bottomland hardwoods of the Mississippi and Platte Rivers
   - prairie potholes
   - riparian corridors (only a few remaining)

4. Remnant central hardwood forest (virtually none left)

Habitat Values and Trends

The Corn Belt States of the Midwest have sustained the greatest conversion of terrestrial environments to human land uses in the nation. The elm-ash forest type in Ohio, Indiana, and Michigan has been reduced by 88% as a result of conversion to agricultural and urban uses (Klopatek et al. 1979). Bluestem prairie and its transition zone with oak-hickory forest has declined by 85% and 78%, respectively, representing a loss of more than 41 million ha, primarily due to conversion to agriculture. The agricultural states of Iowa, Illinois, and Indiana have lost the highest amounts of their natural ecosystems (92, 89, and 82%, respectively).

As with forest habitats, the spatial pattern and fragmentation of prairie vegetation can negatively affect native fauna and ecosystem health. The loss of grassland habitat to agriculture is responsible for the decline in prairie birds, especially those requiring large continuous habitats, and is analogous to the reduction in old-growth forests and its obligate species. The upland sandpiper, bobolink, dickcissel, grasshopper sparrow, savannah sparrow, and Henslow's sparrow all declined by 90% between the 1950s and 1970s (Graber and Graber 1983). Based on 1984 maps (USDA Forest Service 1989), the average number of endangered and threatened species per county is 2.4 for the Midwest Habitat Region, the lowest in the nation. Many historical species, however, have been extirpated from the Midwest.

Therefore, the few remaining natural areas are the major contributors to the diversity of the region. These areas include isolated examples of savanna, grasslands, and forests.

Savanna

Oak savanna once covered between 11 and 13 million ha of the Midwest in the states of Minnesota, Iowa, Missouri, Illinois, Wisconsin, Michigan, Indiana, and Ohio (Nuzzo 1986). It is now the rarest major habitat type in the Midwest; in 1985, only 113 sites totaling 2,607 ha of high-quality oak savanna remained in the Midwest, representing 0.02% of its original extent. Oak savanna is dominated by oaks producing 10 to 80% canopy, with or without a shrub layer, and has a herbaceous, predominantly grassy ground layer of prairie or forest species. Because savanna is fire-dependent, it rapidly converts to forest without fire or severe droughts. This occurred over much of its range within 40 years of settlement. Fire was eliminated by plowing and grazing, and by the construction of roads and railroads, which act as firebreaks. Other than a few areas with the appropriate moderate grazing or occasional fires, existing savanna occurs only on droughty sandy or rocky soils.

Grasslands

Prairie habitats constitute another important regional habitat that is greatly reduced in area. Only minor remnants of the vast area of tallgrass prairie remain. Restoration activities, a major component of prairie conservation efforts, have been attempted (1) by upgrading existing degraded prairies, and (2) by establishing prairie communities on sites without existing prairie species (Kline and Howell 1987). In addition to planting and site preparation techniques, fire is an essential tool in prairie restoration. Unfortunately, most restored prairies contain unwanted species and require special management involving site preparation and fire to address exotic herbs and woody species, respectively.

Forests

Merritt (1980) described the forests of the central region of the United States as comprising 40 million ha of the originally greater than 140 million ha of hardwood forest, or about 15% of the total land area [however much of these forests occur outside the Midwest Habitat Region in the states of Kentucky and Arkansas]. These forests have a long history of disturbance from Indian and European slash and burn systems, plus livestock grazing and logging. Throughout the Midwest, both the hilly well-drained soils and the more fertile wetter, glaciated areas have been cleared for agriculture. Woodlands not cleared for farming were heavily timbered. By the 1930s, permanent clearing had created the most fragmented forest system in the United States.

The most extensive forest type, oak-hickory, makes up 72% of the forest acreage, while elm-ash-cottonwood occupies about 17%. Today, woodlands are limited in size, are widely dispersed, and occur primarily in the portions of the land that cannot be easily worked for row crops. Along the prairie fringes, wooded areas are located on steep bluffs and ravines and along poorly drained bottomlands. Elsewhere, they are found on rough and rocky land, on poorly drained uplands, along stream banks, and on bottomlands subject to overflow. These few remaining forests are especially important because of their role as riparian areas in the ecological functioning of the watershed. Nationwide 70% to 90% of riparian areas have been lost to human activities (Ohmart and Anderson 1986).

Even in the last 25 years, total Midwest forest has continued to decline. Only 100,000 ha or 0.07% of the original central hardwood old growth remains, mostly in protected areas that were once family farms. The long-term viability of this forest type is in question due, in part, to the "natural" change from oak-hickory to sugar maple (perhaps from reduced fire or climate change) occurring on mesic sites. Degradation is continuing from recreational overuse and vandalism, and from adjacent impacts such as urban construction, soil erosion, agricultural chemicals, land drainage, and strip mining for minerals (Parker 1989).

Wetlands

Prairie wetlands, located in the glaciated portion of the states of North Dakota, South Dakota, Minnesota, and Iowa, constitute the single most important breeding area for waterfowl in North America (Hubbard 1988). These wetlands support 50% to 80% of the continent's duck populations as well as many other wildlife species such as nongame birds, muskrat, and mink. These wetlands, or prairie potholes, are relatively shallow, water-holding depressions varying in size, water permanence, and water chemistry. Refilling usually occurs from spring precipitation and runoff, and water levels fluctuate widely due to climate variability (Poiani and Johnson 1991).

Other wetlands include diverse shallow wetlands, ponds, and lakes that were glacially formed, and bottomland hardwoods. The peak loss in bottomland hardwood habitat occurred in the 1970s and 1980s, and losses have declined since then for economic reasons.

Activities and Impacts Affecting Habitats

The following activities result in major impacts on habitats of concern in the *Midwest Croplands*:

- Conversion to agriculture and offsite impacts of cultivation practices (especially to aquatic systems).
- Urban development, both residential and commercial (particularly in large metropolitan areas such as Chicago, St. Louis, Cleveland, and Minneapolis-St. Paul).
- Forest loss and fragmentation (especially to highway development and channelization of riparian areas).

The major impacts of degrading activities on the principal habitats of concern are summarized in the table below.

IMPACTS ON HABITATS OF CONCERN IN THE *MIDWEST CROPLANDS*					
	Land Conversion	Timber Harvesting	Grazing	Water Management	Other
Oak savanna	Major conversion to agriculture	Moderate	Moderate	Minor	Succession to forest after fire suppression
Prairie	Major conversion to agriculture	None	Major	Minor	Invasion of exotic species
Wetlands	Major conversion to agriculture and urban uses	None	None	Drainage for land conversion	Minor
Remnant forests	Conversion to agriculture	Removed prior to agriculture	None	None	Minor

Land Conversion

Historically in the Midwest, conversion to agriculture has been a major factor affecting habitat loss. In Illinois and Indiana more than 80% of the natural ecosystems have been lost to agriculture. Conversion to agriculture is continuing on the fence rows and ditch banks that remain. Odd-dimensioned plots are now being converted as a result of monetary incentives in Wisconsin and other states (Todd Peterson, personal communication). During the Illinois state inventory of prairies, lands were disturbed for railroad maintenance or converted to agricultural fields faster than they could be identified. These conversions represent the loss of the only remaining wildlife habitats in many areas (Illinois Department of Conservation 1978). This is especially true of bottomland hardwoods, which were also affected by channelization and timber harvesting. Logging continues on the last large tracts of forest, including accelerated development via barge canal along the lower Kaskaskia River (the largest remaining tract of bottomland timber in Illinois). The loss of riparian areas has resulted in declines among the waterfowl of the Mississippi Flyway.

Approximately 60% of North Dakota's original 5 million ac of prairie pothole wetlands has been lost (Stromstad and Donovan, 1989). Agricultural development accounts for nearly 99% of prairie pothole losses. In northeastern Illinois, 20% of wetlands identified by aerial photos were filled for construction between 1970 and 1974. Instances of new wetland drainage appear to have dropped significantly; however, upland grasslands adjacent to wetlands are still significantly at risk. Approximately 50% of the grasslands in the Missouri Coteau of North Dakota were converted to cropland between 1965 and 1975. Loss of grasslands, hayed and grazed for livestock production, adversely affect many species, including the elimination of upland nesting cover for ducks. Some limestone glades are being quarried; hill prairies are being used for homesites; railroad prairies face new maintenance threats from herbicides and heavy machinery; and new lands are now being cultivated.

Agricultural Impacts

Both the extensive coverage and intensive use of agricultural land in the Midwest pose additional stresses to habitats through cultivation practices (NRC 1982). The use of fertilizers and pesticides, irrigation and drainage, double cropping and increased field size all contribute to increased pollutant loads and severe impacts on habitats. Agricultural chemicals are toxic to many species and can negatively affect population levels, community composition, and ecosystem dynamics. Other intensive cultivation practices directly reduce important hedgerow and riparian habitat and usually produce severe offsite impacts.

Impacts on Aquatic Systems

The intensive use of midwestern lands converted to human uses has resulted in a high level of pollution discharge and other negative impacts on aquatic systems. A historical example is the degradation of the Illinois River through intensive human use from Chicago, including sewage discharge, dredging, damming, barge traffic, and introduction of carp. As a result, half of the original 400,000 ac were drained, and the other half of the sand-bottom backwaters of the river were covered with mud.

Smaller streams throughout the Midwest have also been severely degraded through the impacts of agricultural practices and urban expansion. In particular, fish populations have been extirpated by the following factors (in order of relative importance):

- Siltation.
- Drainage of wetlands.
- Stream desiccation due to lowered water tables.
- Competition and hybridization due to habitat changes and introduction of exotic species.
- Pollution.
- Dams and impoundments.
- Raised water temperatures with removal of streamside vegetation.

Mitigation of Impacts

The conservation of habitats requires consideration of mitigations for the major activities impacting habitats of concern. In the Midwest Habitat Region, the primary habitat impacts are due to the following:

- Conversion to agriculture and offsite impacts of cultivation practices.
- Urban development, both residential and commercial.
- Forest loss and fragmentation.

In the Midwest, habitat conservation of oak savannas and prairie types is essentially a restoration and creation effort. Less habitat of high ecological integrity remains in the Midwest than in any other region except the central valley of California and parts of Florida (Steve Chaplin, TNC, personal communication). Restoration of grassland systems concentrates on revegetation and borrows largely from agriculture and horticulture (Jordan et al. 1988). The most commonly measured parameters at restoration sites are the survival and growth of planted vegetation for the first few growing seasons, generally too short a period to evaluate the ultimate species diversity or the presence of self-regeneration. More successful has been the use of a "prairie matrix" (developed by Robert F. Betz) of a few aggressive and tolerant native species that survive weed competition too intense for many other native plants (Packard 1988). Restorationists follow this matrix with less aggressive species to effectively shorten the natural ecological succession of prairies.

Degradation of remnant forest is continuing from recreational overuse and vandalism and from adjacent land-use practices such as urban construction, soil erosion, agricultural chemicals, land drainage, and strip mining for minerals. Research is needed to determine whether important mitigation factors (e.g., adjacent harvest, increased access through new roads, different harvest systems, and width of buffers) can be applied (Parker 1989).

Land Conversion

Effective mitigation of land conversion activities can sometimes be obtained only by avoiding impacts on rare or unusual habitat types. Rarely, if ever, is restoration or compensation an adequate mitigation for the loss of these habitats. In these cases, mitigation is a siting issue, where construction and degrading activities are located at a distance from the habitats of concern. The habitat is adequately preserved if all possible impact scenarios are accounted for. Barring this solution, effective management measures must be implemented to ensure the protection of the habitats of concern.

In the case of unique riparian or wetland habitats, hydrological and contamination concerns are especially important. Construction or resource management activities require the use of sediment filter strips and other means of intercepting offsite contaminants. Road building and structural "improvements" must not result in altered hydrological regimes. Where rare plant types exist or where habitats are unstable, recreational access may have to be limited. These mitigations can be best implemented by creation of a regional land-use plan (through a coordinating council like the Waterfowl Flyway Council) and landowner incentives (like the Conservation Reserve Program).

Conversion to agricultural land is a special concern in the Midwest. Land conversion to agriculture can cause ground water overdraft, salinization of topsoil and water, reduction of surface water, high soil erosion, and destruction of native vegetation. Mitigations include more conservative irrigation techniques and improved drainage systems. Soil conservation techniques vary from windbreaks to contour plowing, stripcropping, rotation of crops, conversion to grass, and/or minimum tillage.

Agricultural Impacts

Maintenance of riparian areas and habitat corridors is effective mitigation for intensive agriculture. Implementation of integrated pest management (IPM) practices can reduce the load of toxic agricultural chemicals entering both terrestrial and aquatic systems. In general, institution of best management practices (BMPs) that address nonpoint source pollution are appropriate mitigations for impacts caused by cultivation practices.

Wetlands

Mitigation of wetlands destruction and degradation is the subject of a growing body of literature (Kusler and Kentula 1989). Restoration and mitigation banking concepts are still being evaluated as effective mitigation measures for direct wetlands alterations.

Guidelines for Reviewers

Reviewers of environmental impact assessments will find this document useful if they follow the steps laid out in the introduction:

1. Review the status and trends of habitats in the region.

2. Identify the habitats of concern.

3. Link the activities involved with impacts to these habitats of concern.

4. Devise appropriate mitigations for the impacts.

Each reviewer can then determine the adequacy of the environmental impact assessment in question and recommend modifications to enhance its effectiveness.

In identifying the habitats of concern, the reviewer should supplement the information in this document with detailed locational information on the abundance and distribution of habitats within the region of interest, and with any historical information on the extent and quality of these habitats. Most important, the reviewer should characterize the habitats in terms of their ecological values (e.g., use of wooded wetlands by migratory waterfowl).

In considering the links between activities and habitats, the reviewer should look beyond direct impacts to indirect and subtle effects, including cumulative impacts, interactive and synergistic impacts, and scale-dependent impacts (e.g., effects of fragmentation on ecosystem integrity and species home ranges).

In devising possible mitigations, the reviewer should follow the seven principles for habitat mitigation repeated below. The reviewer should also determine whether adequate assurances have been given that the mitigations proposed will be completed.

1. Base mitigation goals and objectives on a landscape-scale analysis that considers the needs of the region.

2. Mimic natural processes and promote native species.

3. Protect rare and ecologically important species and communities.

4. Minimize fragmentation of habitat and promote connectivity of natural areas.

5. Maintain structural diversity of habitats and species diversity, where appropriate, to promote the natural variety of the area.

6. Tailor management to site-specific environmental conditions and to the unique impacts of the specific degrading activity.

7. Monitor for habitat impacts and revise mitigation plans as necessary.

Finally, the reviewer should consider the proposed activities and mitigations in the context of relevant regional program goals and objectives (e.g., whether the outcome of the project will be in accordance with principles set out by regional planning commissions).

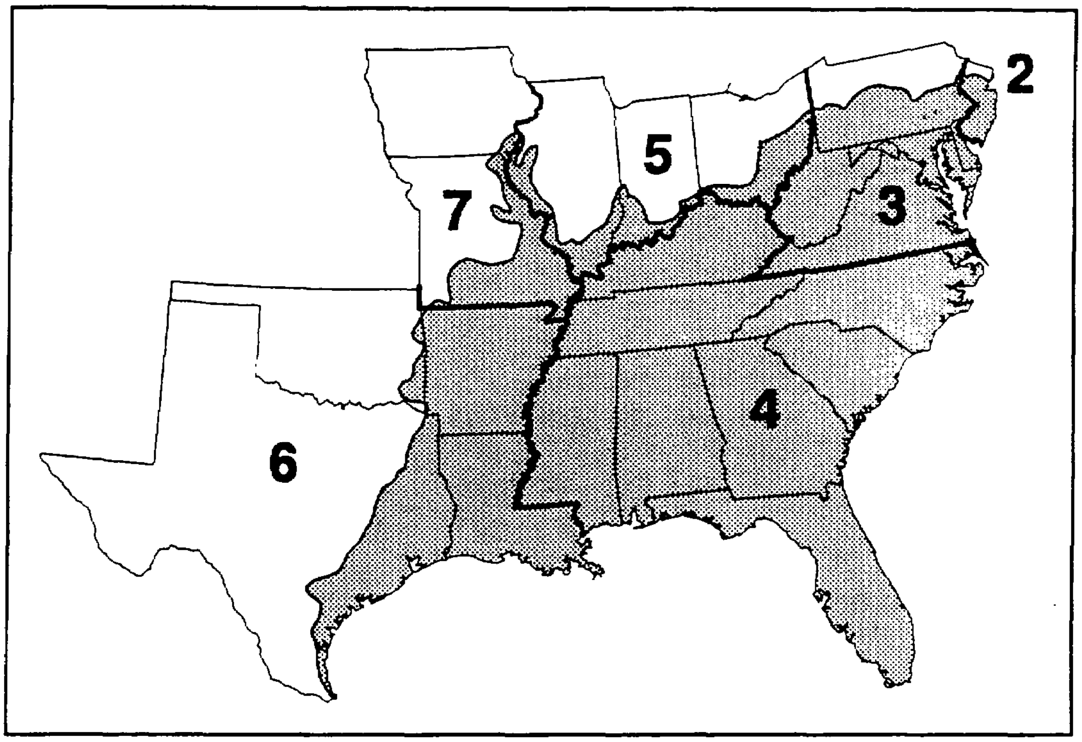
Contacts and Information Sources

When considering habitat conservation issues in an environmental impact assessment for the *Midwest Croplands*, the reviewer should consult the following organizations and individuals for information on habitat impacts and mitigations:

State Natural Heritage Programs
U.S. Fish and Wildlife Service, Regional and Area Offices
State Fish and Game Departments
University and Research Programs
Herbaria and Museums

Steve Chaplin, Regional Zoologist, The Nature Conservancy
Mamie Parker, Division of Federal Activities, U.S. Fish and Wildlife Service Region 3

Southeast Habitat Region: *Southeastern Forests and Croplands*



Geographical Description of the Region

The Southeast Habitat Region, *Southeastern Forests and Croplands*, contains all of 14 states (and the District of Columbia) and parts of 9 states. The region includes all of Maryland, Delaware, District of Columbia, Virginia, West Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Alabama, Mississippi, Florida, Louisiana, Arkansas, and parts of New Jersey, Pennsylvania, Ohio, Indiana, Illinois, Iowa, Missouri, Oklahoma, and Texas. EPA Region 4 is included in its entirety, and parts of EPA Regions 2, 3, 5, 6, and 7 also are included. The accompanying map indicates the boundaries of this habitat region and the states it comprises.

The *Southeastern Forests and Croplands* is perhaps the most diverse in the nation comprising 20 ecoregions (Omernik 1987). The vegetation of the region includes a wide range of forest types, including Appalachian oak, oak/hickory/pine, mixed mesophytic forest, southern mixed forest, southern floodplain forest, as well as palmetto prairie and everglades. Northern hardwoods and southern mixed and floodplain forests are also present. The land use pattern is mostly a mosaic of forest and cropland with substantial woodland, pasture, swampland, marshland, and urban components.

Habitats of Concern

The *Southern Forests and Croplands* contains many habitats of concern; the most obvious fall into eight general categories. The principal habitats of concern most at risk in the *Southern Forests and Croplands* are listed below.

PRINCIPAL HABITATS OF CONCERN
IN THE *SOUTHEASTERN FORESTS AND CROPLANDS*

1. Bottomland hardwoods
   oak/gum/cypress

2. Scrub habitat
   Florida sandpine scrub
   southeastern savanna and bogs

3. Spruce-fir forest in the Appalachians

4. Old-growth pine forest
   longleaf pine-wiregrass
   New Jersey pine barrens

5. Everglades ecosystem
   other wetlands

6. Maritime forest of coastal barriers

7. Contiguous upland hardwood forests

8. Mature mixed mesophytic Appalachian and Ozark forest
   subalpine, barrens, and caves
   old-growth forest

Ecosystems of concern include the Chesapeake Bay and major river systems, abundant freshwater and coastal wetlands, relict closed boreal subalpine forest communities, limestone barrens, remnant alpine peat bogs, and the Great Dismal Swamp. Also, the endemic communities in the Southern Appalachians, high-elevation spruce-fir forests (boreal subalpine), bottomland hardwood forests, coastal live oak forests, long-leaf pine wiregrass hardwood hammocks, and the Everglades. Oak-gum-cypress forests of the lower Mississippi drainage are important overwintering habitats for avian species.

Habitat Values and Trends

Two to three centuries ago, almost all of the land area in the South was forested. Since that time, agricultural land has become an increasingly prominent part of the landscape (USDA Forest Service 1989). The loss of forested area accelerated in the late 1800s with the harvesting of old-growth forests. However, after 1920 forest area began to increase with the abandonment of agricultural land, reduced timber harvesting, and efforts to regenerate forests. This trend continued until the 1960s, when abandonment slowed and new clearing for agriculture and pastureland began (at first among bottomland hardwoods and later more uniformly across the South). Concomitant increases in population and industry saw large areas converted to residential and commercial uses. Future economic conditions will likely determine whether high rates of conversion continue. Projections for the next 50 years show urban area increases of 14 million ac leading to losses of several million ac each in cropland and pastureland. These losses may stimulate forest conversions for additional agricultural land; in particular, forests of the Ozarks are expected to be converted to pasture (NRC 1982).

Forests

The Southeast contains 200 million ac of forest land with 62 million ac in pine forest (loblolly-shortleaf pine, longleaf-slash pine, and oak-pine), 71 million ac in oak-hickory, and 31 million ac in bottomland hardwood types (USDA Forest Service 1989). Since 1963, losses in the Southeast have occurred in longleaf-slash pine (40%), oak-gum-cypress (24%), and loblolly-shortleaf pine (15%). Bottomland hardwoods have been lost to agricultural clearing, and most remain only as strips along streams where the soil is too wet for cropping or grazing. They are further endangered by dams and drainage modifications. The loss of longleaf pine habitat can be attributed to the logging of nearly all original forest from the Atlantic coast to the Piney Woods of Texas and the replacement with loblolly and slash pine. Losses of other pine species are the result of poor pine regeneration and less farmland abandonment.

The forests of the *Southeastern Forests and Croplands* contain a particularly diverse fauna and flora. Many northern species complexes reach their most southern extent in the southern Appalachians, while many southern species reach their most northern extent at Cape Hatteras. Based on 1984 maps (Flather and Hoekstra 1989), the average number of endangered and threatened species per county is 5.7 for the *Southeastern Forests and Croplands*. The following listing of southeastern forest types illustrates some characteristic ecological values of the region:

- Loblolly-shortleaf pine - much of the ecosystem has been converted to pine plantations, often mixed with pasture or row crops.

- Longleaf-slash pine - covers the coastal region and has an extensive grassy understory that varies with site and geographic location; it supports many endemic plants and endangered animals including red-cockaded woodpecker and Florida panther; nearly eradicated in logging boom of the early 1900s, it was replanted in loblolly or shortleaf pines; slash pine now dominates this ecosystem.

- Oak pine - often occurs on cutover sites with poor pine regeneration; supports white-tailed deer and wild turkey.

- Oak hickory - supports southern bald eagle, red wolf, red-cockaded woodpecker; is widespread with at least six distinct associations.

- Bottomland hardwood - principally oak-gum-cypress and elm-ash-cottonwood ecosystems; mangrove swamps in Florida support Florida manatee, brown pelican, bald eagle, hawksbill sea turtle, and Atlantic Ridley sea turtle; cypress savanna has been mostly converted to pasture and cropland, but remaining areas support fox squirrel, ibises, cormorants, herons, egrets, kingfishers, Bachman's warbler, Florida panther, and bald eagle; elm-ash-cottonwood supports many waterfowl species.

Although the logging of mature forests may increase site diversity by creating forest edge, these timber harvesting activities usually increase the number of species that are not in need of protection (e.g., white-tailed deer, bobwhite quail, cottontail rabbit, gray squirrel, wild turkey) at the expense of species that are regionally, as well as locally, rare or vulnerable. As is the case with old-growth Douglas fir in the Northwest, the decline of subalpine Appalachian forests threatens the last remnants of historical ecosystems, the loss of which would dramatically lower regional and global diversity.

Of particular concern in the Southeast are (1) old-growth-dependent species (such as the red-cockaded woodpecker in coastal plain pine forests), and (2) forest-interior-dependent species (including many neotropical migrant songbirds in mixed deciduous forests). Because of their ecological complexity and relative isolation, southeastern forest ecosystems contain many rare and endangered species that require mature trees for nesting and foraging. Mature trees are at serious risk from logging in the *Southeastern Forests and Croplands*; though sustainable short-rotation plantation forestry dominates the region, remaining areas of mature forest are still being sought and exploited for short-term profits.

The habitat of the red-cockaded woodpecker, which exists in the southern pine forests ranging from Maryland to Texas, has been reduced and will continue to decline under current timber harvesting management practices (Roise et al. 1990). The causal factor in habitat loss is the cutting of loblolly pine-dominated stands greater than 75 years of age, and the cutting of all longleaf pine stands greater than 95 years of age. Lennartz et al. (1983) estimates that pines required by the red-cockaded woodpecker have declined by 13% in 25 years. In Texas, clear-cut logging has been restricted because of concerns for the red-cockaded woodpecker (Larmer 1989).

Species described as interior forest birds (Terborgh 1989) are of special concern in forest environments suffering from fragmentation. Songbirds, in particular, are declining in number because of the loss and fragmentation of forest habitat along their migratory path from New Hampshire to Mexico. Forest conversion and fragmentation leads to an increased likelihood of starvation and an increased likelihood of predation due to an increase in the numbers of songbird predators (Terborgh 1974). Robbins et al. (1989) summarized the breeding habitat losses and requirements of forest birds of the Middle Atlantic States in light of the negative effects occurring from forest fragmentation (due to suburban expansion) in that region (Lynch and Whitcomb 1978). They concluded that in relatively undisturbed mature forests, the degree of isolation and the area of forest were better predictors of relative abundance of bird species than were any habitat variables. Forest reserves of thousands of hectares are required to have the highest probability of providing for the least common species of forest birds in a region.

Bottomland hardwood forests represent a third important forest habitat of the Southeast, one that supports many bird species during the critical over-wintering period. The oak-gum-cypress ecosystem of the southern states also includes a diverse resident avifauna (Dickson 1988). For example, this habitat was the historical range of the ivory-billed woodpecker. The forests of the Appalachian and the Ozark regions also contain valuable habitats.

The Appalachian Plateau has special value because its cool, wet climate at 2,400 ft allows northern species to live at lower latitude. Encompassing more than 230 terrestrial vertebrate species, this region has the richest floral, breeding bird, mammal, and amphibian communities of any upland eastern U.S. forest type (Hinkle et al. 1989). More than 60% of the breeding birds are neotropical migrants. The mature mixed mesophytic forest contains many old-growth areas and unique habitats such as subalpine, montane grasslands, serpentine areas, shale barrens, mountain peatlands (supporting unusual plants and animals: larch, wild calla, cotton grass and northern water shrew), vernal ponds (rare amphibians and invertebrates), sandstone ridgecrests (rare plants), and caves (globally rare aquatic amphipods) (The Nature Conservancy, Maryland Chapter 1991.)

The forests of the Ozark region (encompassing southern Missouri and northern Arkansas) were once vast tracts of white oaks and shortleaf pines, but today they exist as a mosaic of relatively young vegetation in various stages of succession (Smith and Petit 1988). At the turn of the century, the region experienced perhaps the most extensive destruction of forest through clearcutting on the continent. This resulted in the loss of many bird species dependent on mature forest and the increase of species adapted to open environments. Of the forest birds that have survived the transformation to a mosaic of young forest, the broad-winged hawk and hooded warbler are at risk from increased habitat fragmentation and conversion of hardwood forest to pine plantations.

Grasslands, Barrens, and Scrub Habitats

In addition to mature forests, terrestrial habitats of significance in Maryland and other mid-Atlantic states are shale barrens, barrier islands, serpentine areas (rock outcrops), peat lands, floodplains, and sandstone glades. Serpentine sites represent the kind of unusual local environments that produce unique habitats throughout the region. A relatively high percentage of vascular species on state natural heritage program lists and on the candidate lists of threatened and endangered species of the United States are serpentine endemics. Currently, more than 400 communities are listed in the Maryland Natural Heritage Program database with another 200 species having been extirpated (Janet McKegg, Maryland Natural Heritage Program, personal communication). Many other important communities are aquatic or riparian (e.g., the Delmarva bays), but are often better protected by federal and state wetlands regulations. The New Jersey Pine Barrens is another region with many important local habitats. This pinelands ecosystem comprises a mosaic of upland, aquatic, and wetland environments covering more than 400,000 ha (McKenzie 1981).

Sandpine scrub is one of the nation's most threatened habitats; it is found only on scattered knolls of coastal and inland Florida and adjoining Alabama and Georgia (Bass 1988). It has been reduced to one-fifth of its original acreage by expanding agriculture and industry. Along with mahogany hammock, sandpine scrub is also the least recoverable of habitats in Florida. It has perhaps the highest concentration of endemic plants (including many that are endangered or threatened) of any place in the United States. Development is the principal threat, and landowners are bulldozing areas to prevent federal protection of undisturbed scrub. The scrub is already vulnerable because the natural burn cycle of the scrub has been disrupted by fire suppression practices. This vegetation type requires burn cycles of 30 to 80 years to allow dominants to reproduce but at the same time to prevent canopy closure.

Savannas and bogs of the southeastern coastal plains are also habitats sensitive to fire management. Without fire they are invaded by fire-intolerant trees. These ecosystems are home to many endemics, such as carnivorous plants. Approximately 97% of southeastern savannas and bogs no longer exist, having been converted to pine plantations or pastures through drainage or to farm ponds in hillside bogs.

The only substantial rangelands in the Southeast (4 million ac or 13% of the total area) are the wet prairies and marshes along Atlantic and Gulf coasts that include the Everglades and palmettos prairie of southern Florida. Louisiana and Texas also possess significant portions of this ecosystem; unique species include the golden-cheeked warbler, Texas red wolf, Attwater's prairie chicken, Florida panther, Florida great white heron, Everglades kite, plus the more common collared peccary, coatimundi, and pronghorn antelope. Species of concern include subtropical natives suffering population declines due to the loss of habitat and invasion by exotic species. The region also contains many freshwater and marine habitats, and is unique in the number and diversity of its wetland habitats.

<u>Wetlands</u>

Specific southeastern wetland problem areas identified by Tiner (1984) include the following:

- Estuarine wetlands of the U.S. Coastal Zone.
- Louisiana's coastal marshes.
- Chesapeake Bay's submergent aquatic beds.
- South Florida's palustrine wetlands.
- Forested wetlands of the Lower Mississippi Alluvial Plain.
- North Carolina's pocosins.

In the Southeast, 86% of the forested wetlands are in the coastal plain (Tansey and Cost 1990). In the last 10 years, 16% of the area has been converted to nonwetlands through changes in species or hydrology, including harvesting. Large losses of forested wetlands in the Lower Mississippi Valley have occurred with the conversion of bottomland hardwood forests to cropland. Of the 11.8 million ac of bottomland hardwood forest in 1937, only 5.2 million ac remain, including 60% in seasonally flooded basins or flats and 40% in wooded and shrub swamps. These decreases in acreage were matched by increases in croplands, principally soybeans, and corresponded to the completion of major Corps of Engineers flood control projects and smaller watershed projects. Indirect effects of these projects (clearing by landowners in anticipation of flood protection) exceeded losses to direct construction. The rate of loss continues to increase in Louisiana.

Shrub wetland losses are greatest in North Carolina owing to the conversion of pocosins to cropland and pine plantations and their mining for peat. The drainage of inland marshes is greatest for the Florida Everglades. Indeed, the modifications to the water drainage patterns beginning in the headwaters of Kissimmee basin through Lake Okeechobee to the Everglades are some of the most extensive in the country. Additional losses of mucky bottomlands, marshes, and dunes across the coastal plain have decreased duck populations, flood control, and water supply. More than 50% of Texas wetlands (including bottomland hardwoods and coastal marshes) have been lost (Loftis 1991). In the Gulf

Prairies and Marshes region, much of cordgrass marshes are drained and barrier islands overgrazed resulting in severe soil erosion.

Aquatic Systems

Approximately 24 million ac of water area are contained in the lower Mississippi River and tributaries, the lakes and waterways of the Mississippi Delta, the large number of small and large lakes in Florida, the numerous large water impoundments, the small ponds and streams, and the Atlantic and Gulf coastal waters (one-fifth of this area) of the *Southeastern Forests and Croplands*. The many unique aquatic habitats make this region the most diverse in the nation.

The marine systems in the Southeast are exceptional and include the unique coral reefs of Florida. A 5-year study on the Florida Keys coral reef by University of Georgia and Florida Institute of Oceanography indicates a 10% per year decline in some parts of the reef and predicts possibly irreversible endangerment in the next decade (Keating 1991). Threats include pollution (especially nutrients from sewage and agriculture that stimulate algae overgrowing), sedimentation (from erosion via forest and shoreline conversion that smothers corals), diseases (possibly aggravated by water quality stresses), and weather (including global warming).

Activities and Impacts Affecting Habitats

The major sources impacting habitats in the *Southeastern Forests and Croplands* include residential, industrial, and commercial developments, logging and silviculture practices, agricultural activities, mining practices, and interstate highway or expressway construction. These activities have produced adverse impacts on species populations and their behavior, as well as on ecosystem processes such as energy flow and nutrient cycling. They have also contributed to the proliferation of nuisance plants and animals. In its comparative risk analysis for the mid-Atlantic states, EPA Region 3 (1988) ranked adverse effects on ecosystems as high from silviculture, coal mining, and conversion to urban uses through residential construction; as moderate from agriculture, mineral mining, second homes development, dam construction, and recreation; and as low from oil and gas development, bridge construction, and water use. In the more southern states, timber harvesting and agriculture have even greater impacts on habitats. In the Gulf Coast States, oil and gas production is a major activity degrading coastal environments.

The following activities result in the major impacts on habitats of concern in the *Southeast Forests and Croplands*.

IMPACTS ON HABITATS OF CONCERN IN THE *SOUTHEASTERN FORESTS AND CROPLANDs*

	Land Conversion	Timber Harvesting	Mining	Water Management	Other
Bottomland hardwoods	Conversion to agriculture	Moderate	None	Impacts of impoundments and siltation dams	Minor
Scrub habitat	Conversion and fragmentation for residential development	None	None	Minor	Minor
Spruce-fir forest	Conversion for resort development	Moderate	None	None	Acidification
Old-growth pine forest	Moderate	Conversion to short rotation plantations	None	Minor	Military activities
Everglades and wetlands	Urban and agricultural conversion	Minor	Peat mining of pocosin wetlands	Impacts of water diversions altering hydrology	Invasion of exotic species
Maritime habitats	Conversion for coastal development	Minor	None	Minor	Recreational activities
Contiguous forest	Fragmentation from urban sprawl and highway development	Fragmentation	Fragmentation	Minor	Minor
Appalachian and Ozark forests	Conversion to plantation silviculture	Major	Major impacts of coal mining	Minor	Minor

Land Conversion

Historically, land conversion of both uplands and wetlands has profoundly affected the natural communities in the Southeast. In recent years, the boom of population growth has caused increased conversion of natural areas to industrial and residential development. Rapidly growing areas in Florida and certain SunBelt cities are suffering intense "spin-off development" associated with highway development, a process that is rapidly expanding into previously rural areas. This increased road construction is causing severe fragmentation of sensitive environments such as the North Carolina pocosins and the Florida sandpine scrub. The sum of this massive habitat alteration in areas such as south Florida has been a dramatic reduction in not only large mammals and birds but also reptiles and amphibians (Crowder 1974). Conversion of bottomland hardwoods to agriculture continues to be a significant cause of habitat loss that has detrimental effects on the waterfowl of the Mississippi Flyway.

Agricultural and Grazing Impacts

The use of agricultural land in the Southeast poses additional stresses to habitats through cultivation practices (NRC 1982). The use of fertilizers and pesticides, irrigation and drainage, double cropping, and increased field size all contribute to increased pollutant loads and severe impacts on habitats. Agricultural chemicals are toxic to many species and can negatively affect population levels, community composition, and ecosystem dynamics. Other intensive cultivation practices directly reduce important hedgerow and riparian habitat and usually produce severe offsite impacts. Grazing has a lesser impact on the region as a whole but is increasing in the south Florida prairies and oak hammocks west of the Everglades.

Timber Harvesting

Timber harvesting activities are another major cause of habitat loss in the *Southeastern Forests and Croplands*, affecting many sensitive forest types. For example, the southeastern mixed forest and the Ozark forests are being converted to pine monocultures. Logging also continues in the southern Appalachian subalpine forest and some bottomland hardwood forests. These impacts affect 90% of the total bird, amphibian, and fish species and 80% of mammal and reptile species that utilize forest ecosystems (U.S. Forest Service 1989).

In addition to the direct destruction of forests through land conversion, timber harvesting activities can fragment, simplify, and degrade forest habitats. The faunal communities inhabiting forests vary with the successional, or seral, stage. Because the principal impact of timbering practices is to convert forest stands from latter to earlier seral stages, logging has a major impact on resident animal as well as plant species. Timber harvesting telescopes plant succession, shortens rotations, compresses seral stages, and decreases the proportion of old growth. The conversion of hardwoods to conifers creates structurally simplified plantations that reduce structural diversity and wildlife. This has produced a trend away from declining habitat types and toward common habitat types. Management for monotypic even-aged stands causes increases in forest pest damage that can result in large-scale spraying and the accompanying impacts. Logging activities also impact nearby aquatic systems through erosion and sediment transport.

Logging in the national forests of Texas relied exclusively on clearcutting and its variations until 1988. The general practice was to convert the natural complex forest systems (tall pines with oak, ash, and hickory underneath in diverse groves of 100 broadleaf tree and shrub species) into single-species loblolly pine plantations. Site preparation (including the clearing of all vegetation, concomitant removal of topsoil, application of herbicides, and burning) was conducted to eliminate competition with planted species. This homogenization threatened the long-term health and productivity of the forest by reducing the quality of the gene pool. Because of the susceptibility of monocultures to insect infestation, additional clearcutting was conducted to provide buffer areas around the pine plantations. Between 1978 and 1988, the number of colonies of the endangered red-cockaded woodpecker fell from 455 to 174. Recent court decisions and enlightened foresters are moving away from clearcutting and instituting selective timber harvesting in national forests containing the red-cockaded woodpecker: Texas, Louisiana, Alabama, Mississippi, South Carolina, North Carolina, and Kentucky (Larmer 1989).

Unlike the Pacific Northwest, little research has been conducted on mature eastern hardwood forest (virtually no old growth remains). However, results do show correlations between older forest and the abundance of several species, including great horned and barred owls, pileated and red-cockaded woodpeckers, and common ravens. Declines in other species have been attributed to brood parasitism (by brown-headed cowbirds) and nest predation (by common crows, striped skunks, opossums, black racers, and rat snakes) that occurs along clear-cut edges and in thinned stands. These edge effects are a prominent impact of forest fragmentation. Fragmentation is second only to the decrease in old-growth species as a major impact of timber harvesting activities. The faunal significance of this fragmentation includes discrimination against large-bodied species (e.g., Florida panther, red wolves, mink), genetic swamping by invading species, inbreeding through isolation of populations, and ecological release of middle-sized omnivores.

In addition, there has been the general decline in neotropical migrants that breed in eastern hardwood forests. Although the situation is complicated by losses of wintering habitats for long-distance migrants in Latin America, results indicate that species still present in large blocks of forest are absent from small patches (Robbins et al. 1989). Fragmentation of forest habitat from timber harvesting and from land conversions, especially for transportation, appears to be the major cause of these declines (Terborgh 1989) and has been especially severe in southeastern bottomland forests.

Mining

The greatest single threat to terrestrial habitat in West Virginia and Kentucky is coal mining, projected to increase from 2.4 million ac to 3.4 million ac (4% of total land area) by the year 2000 (McComb et al. 1991). The profitability of timber harvesting will be increased by the transportation infrastructure built for coal mining and the fact that large acreages have reached sawtimber age. This transition sets the stage for an unprecedented combination of cumulative impacts in the central Appalachians in the next 20 to 30 years. Surface mining will be conducted on ridge tops and side slopes; development of single-family housing will occur in valley bottoms; and mature hardwood will be harvested in midslopes and coves. In addition to the direct destruction of forests, the potential for severe soil erosion and offsite impacts is great.

Oil and gas extraction is important on the Gulf coast but rare in other parts of this region. Gold mining is currently causing habitat degradation in South Carolina.

Water Management

Historically, water management activities such as damming and diversion of rivers have had a major impact on the habitats of the Tennessee Valley, the Mississippi River floodplain, and other regions of the Southeast. For example, man's efforts to control the Mississippi River's flooding regime, enhance its navigation, and extract its minerals have led to a rapid deterioration of Louisiana's coastal environment. Wetland loss in Louisiana is more than 400,000 ac since 1900; only 45% of the original forested wetlands in Louisiana remain. The primary causal factor in this loss is subsidence of wetlands that are receiving inadequate amounts of sediment from the Mississippi. An accretion deficit results when levee systems and control structures transport sediments to deep Gulf waters.

In the Mississippi Basin (mid-south Alabama, Tennessee, eastern Texas, and Oklahoma), considerable acreages of bottomland hardwoods were lost to reservoir development between 1962 and

1985 (Gosselink and Lee 1987). Dam construction in general changes water flow patterns, causes flooding, and changes salinity patterns; this kills tree seedlings and can convert forest to salt marsh. Water diversion, another activity degrading southeastern habitats, is severely impacting the Everglades. This diversion stems from the competition for water by agriculture and urban expansion.

Military Activities

The large number of military training areas located in the southeastern coastal plain results in significant impacts on old-growth pine forest. Both a reduction in vegetative ground cover and changes in species composition can result from routine operations and military training activities. Concerns for the impacts of tracked vehicle activity and artillery and aircraft noise on the red-cockaded woodpecker recently prompted a Department of Defense conference on the management of this endangered species (Doug Ripley, personal communication).

Mitigations of Impacts

The conservation of habitats requires consideration of mitigations for the major activities impacting habitats of concern. In the *Southeastern Forests and Croplands*, the primary habitat impacts are caused by the following:

- Timber harvesting of old-growth or mature forests.
- Land conversion of scrub, coastal, and wetland habitats.
- Fragmentation of contiguous forest.
- Mining and acidification of Appalachian forest.

Timber Harvesting

At a minimum, the production of commercial wood products from an area must not exceed the sustainable level if the ecological integrity of a forested area is to be maintained. Where sensitive forest types exist, logging may be completely prohibited or constrained to specific methods to prevent habitat loss or degradation. In other areas, more extreme harvesting methods may be allowed or prescribed to establish or maintain desired forest conditions. Acceptable methods will vary according to local forest ecology and the desired future condition of the site. Analysis of harvesting techniques must be based upon an analysis of the structure and diversity of the forest canopy, midstory, and understory.

A recent directive of the Chief of the U.S. Forest Service acknowledges this fact and points out that clear cutting is acceptable only when needed to replicate natural ecological processes. Selective cutting can preserve forest structural diversity, the primary determinant of wildlife habitat (Harris et al. 1979). However, it can reduce horizontal diversity (NRC 1982). The harvesting technique employed must be based upon sound silvicultural prescriptions and demonstrate its capability to maintain vertical diversity (foliage height diversity), horizontal diversity (interspersion, edge, juxtaposition, patchiness), and a mixture of live and dead wood. Specific timber harvesting operations should be designed to preserve the structure and diversity of the natural forest habitat.

An important component of selective cutting should be the preservation of standing dead trees. Many species of birds nest, roost, or forage for invertebrates in standing trees with decayed wood. These cull trees are usually the first focus of forest thinning operations to the detriment of the birds. Breeding bird abundance declines rapidly following a clear cut, and the species composition continues to change for 10 to 15 years (DeGraaf 1991). However, if trees with cavities are saved, many of these species can successfully forage on sound boles. .About one large cavity or den tree per 2 ha is required for populations of large species such as wood ducks; this requires harvest rotations of 100 to 125 years (although rotations of 65 years produce trees large enough for smaller cavity species).

Timber harvesting practices modified to reduce the impacts of simplification must also address fragmentation. As an example, fragmentation has been especially severe in southeastern bottomland forests (Gosselink and Lee 1987). In this case, the setting aside of undisturbed tracts will not suffice to achieve viable populations of the larger, wider-ranging species. Not only do some species require specific habitat conditions (such as forest-interior species like Bachman's warbler), but others require particular arrangements of several communities. Therefore, a successful faunal conservation strategy must emphasize the landscape configuration, not just the structural content of the communities themselves.

Responding to the "biodiversity crisis," the U.S. Forest Service is moving toward an ecosystem approach to forest management (Bob Szaro, personal communication). Recent forest management plans have incorporated tenets of the "New Forestry" espoused by Jerry Franklin. These progressive plans require the rigorous implementation of ecological management practices to maintain forest productivity and preserve the functioning of sensitive forest components such as old-growth or late-successional forests. Effective mitigations for habitat conservation in forest management require specific management measures at the site, watershed, and landscape levels. For example, the location and size of timber harvests should be planned to minimize reduction of core area of mature forest (e.g., harvest only alternate basins until regrowth). Maintenance of mature-forest stands in managed landscape can be achieved by extending rotation (beyond 80) to 150 to 200 years, by leaving some stands unharvested for old growth, and by linking stands. Landscape-scale considerations include the provision of buffer zones and habitat corridors as discussed in the introduction of this document. Management measures recommended for conserving habitat within managed forests include the following:

- Minimize the construction of new roads and close roads not in use either permanently or seasonally.
- Use best management practices (BMPs) such as filter strips to minimize erosion during harvesting or road construction.
- Maintain 100-ft riparian zones with adjacent feathered transition zones to buffer edge effects.
- Restrict harvesting operations to periods when the ground is either dry or frozen.
- Maintain site productivity by retaining large woody material and minimizing mineral soil exposure and compaction during harvesting.
- Manage for natural disturbance patterns to maintain natural openings and successional-stage composition.
- Maintain connections between blocks of interior forest, especially old growth.

- Provide for the protection of special areas, including cliffs, caves, taluses, riparian areas, and old-growth stands.

- Maintain the structural integrity and the native variety of the forest by managing for the natural composition of the following components: vegetative types, seral stages, tree types and sizes, standing dead trees and down material, tree snags, and cavity trees.

Land Conversion

Effective mitigation of land conversion activities can sometimes be obtained only by avoiding impacts on rare or unusual habitat types. Rarely, if ever, is restoration or compensation an adequate mitigation for the loss of these habitats. In these cases, mitigation is a siting issue, where construction and degrading activities are located at a distance from the habitats of concern. The habitat is adequately preserved if all possible impact scenarios are accounted for. Barring this solution, effective management measures must be implemented to ensure the protection of the habitats of concern.

In the case of unique scrub habitats or coastal systems, hydrological and contamination concerns are especially important. Construction or resource management activities require the use of sediment filter strips and other means of intercepting offsite contaminants. Road building and structural "improvements" must not result in altered hydrological regimes. Where rare plant types exist or where habitats are unstable (e.g., bogs and sand dunes), recreational access associated with nearby development may have to be limited.

Amelioration of impacts from land conversion to transportation uses requires special mitigation measures. As with all land conversion, the construction of highways and power-line corridors is primarily a siting issue. Avoidance of sensitive habitats may be accomplished by modifications to the route design, and the extent of disturbance can be limited by careful construction practices. However, fragmentation of the larger area is unavoidable in the case of land conversion to transportation corridors. Many structural mitigation strategies can be used to lessen the impact on animal movement across transportation routes. Primarily, these include the construction of fences and underpasses. The goal of these structural measures should be to mimic the natural movement and migration patterns of the affected species.

Mining

Mitigation of mining impacts involves siting issues, technological solutions to eliminate contamination, and restoration programs. The major mitigations for oil and gas extraction and production are the proper sitings of rigs, reserve pits, processing facilities, and roads where they will have minimal impacts on habitats of concern. Most important for coal and mineral mining is the siting of mining operations and tailing ponds to avoid habitats of concern, wetlands, riparian areas, and recharge areas. Specific mitigation measures depend on the type of mining and the specific process causing impacts. It is generally best to minimize the area affected as it is unlikely that even the disrupted soils and sediments can be restored. In addition to minimizing the area disturbed, activities should be timed to avoid disturbing nearby plants and animals during crucial periods of their life cycle. Possible mitigation measures for mining operations include the following (SAIC 1991a, 1991b):

- Design of mine entrances and workings to minimize future mine drainage.
- Runon and runoff control measures such as berms and ditches.
- Adequate depth and lining of pits for containment of muds and leachate.
- Elimination of fluid migration through casings and dewatering.
- Separation of wastes and contaminated soils with proper disposal.
- Treatment of leach heaps and neutral or acidic wastewaters to reduce the load of cyanide, nitrates, and heavy metals.
- Closure planning that addresses hydrology, geochemical controls, treatment, and restoration.
- Nets or other covers over process ponds.
- Maintenance of an anaerobic environment in the tailing pile during periods of inactivity.
- Secondary containment of tanks and contingency plans for sudden or catastrophic releases.
- Backfilling and sealing of the mine workings during mine reclamation/closure.
- Recycling of process water, smelter slag, and air pollution control dust.
- Monitoring and elimination of discharges to surface water, groundwater, soils, and air.
- Replenishment of surface and ground waters with treated effluents.
- Road closure and reclamation (following recontouring) with revegetation of native species.

Although the reclamation of mined lands is often unsatisfactory for ecological habitat restoration, reforestation with native trees has been demonstrated (Plass 1973) and would serve to reduce the abundance of nest parasitic brown-headed cowbirds and restrict their access to mature forest.

<u>Military Activities</u>

Mitigation of the impacts of military activities on habitats has only recently received attention. The Army Corps of Engineers' Construction Engineering Research Laboratory in Champaign, IL, is developing a Land Condition-Trend Analysis (LCTA) Program (Diersing et al. 1992) as a comprehensive means of matching military training mission objectives with effective natural resource management. If such a plan is instituted, it is likely that careful coordination of the siting and timing of training operations will dramatically reduce habitat impacts. An awareness of the ecological consequences of specific activities is essential to effective mitigation. The following general mitigation measures apply to the primary impacts of military activity:

- Timing and siting of operations - The noise and disturbance associated with aircraft flights and large troop maneuvers cannot be eliminated. However, sensitive environments can be avoided and operations can be timed to avoid critical nesting and migratory periods.
- Calculation of allowable use for tracked vehicles - Tracked vehicle movements are a major cause of habitat degradation. Vegetation destruction and soil erosion and compaction are the primary impacts. Precise equations can be developed that estimate sustained tracked vehicle use based on physical properties of the environment, vegetative cover, and changes in vegetative cover caused by the passage of tracked vehicles. For example, tracked vehicle use should be restricted to all-weather roads when possible.
- Fire suppression during artillery practice - Fires created by artillery pose a major problem in certain environments. Rapid identification and suppression by helicopter can virtually eliminate the spread of large-scale fires.

Guidelines for Reviewers

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2. Identify the habitats of concern.
3. Link the activities involved with impacts to these habitats of concern.
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Each reviewer can then determine the adequacy of the environmental impact assessment in question and recommend modifications to enhance its effectiveness.

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In considering the links between activities and habitats, the reviewer should look beyond direct impacts to indirect and subtle effects, including cumulative impacts, interactive and synergistic impacts, and scale-dependent impacts (e.g., effects of fragmentation on ecosystem integrity and species home ranges).

In devising possible mitigations, the reviewer should follow the seven principles for habitat mitigation repeated below. The reviewer should also determine whether adequate assurances have been given that the mitigations proposed will be completed.

1. Base mitigation goals and objectives on a landscape-scale analysis that considers the needs of the region.

2. Mimic natural processes and promote native species.

3. Protect rare and ecologically important species and communities.

4. Minimize fragmentation of habitat and promote connectivity of natural areas.

5. Maintain structural diversity of habitats and, where appropriate, species diversity to promote the natural variety of the area.

6. Tailor management to site-specific environmental conditions and to the unique impacts of the specific degrading activity.

7. Monitor for habitat impacts and revise mitigation plans as necessary.

Finally, the reviewer should consider the proposed activities and mitigations in the context of relevant regional program goals and objectives (e.g., whether the outcome of the project will be in accordance with principles set out by regional planning commissions such as those established for the Chesapeake Bay and the Gulf of Mexico).

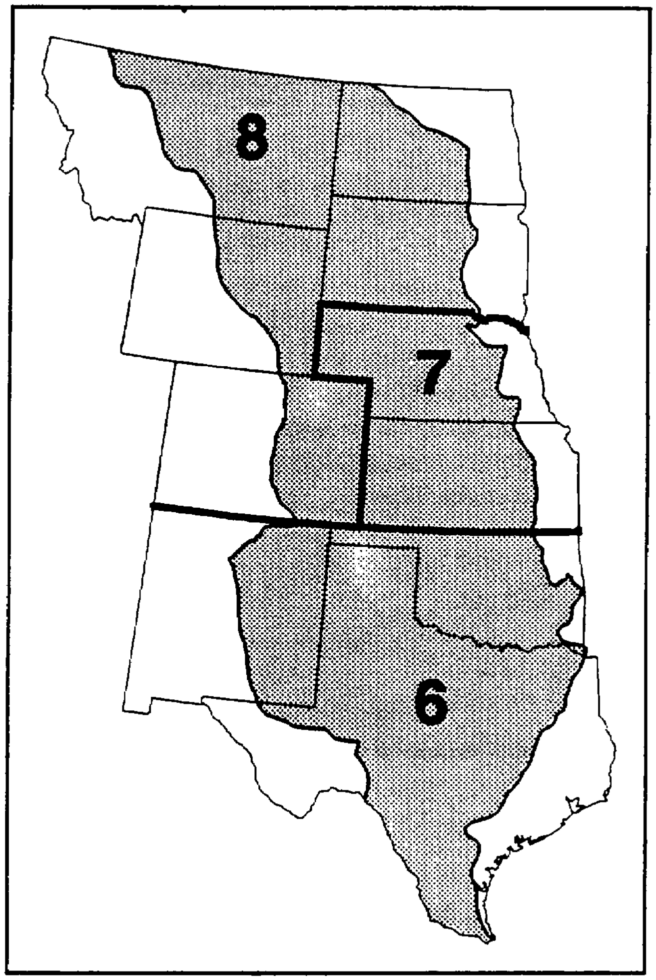
Contacts and Information Sources

When considering habitat conservation issues in an environmental impact assessment for the *Southeastern Forests and Croplands*, the reviewer should consult the following organizations and individuals for information on habitat impacts and mitigations:

State Natural Heritage Programs
U.S. Fish and Wildlife Service, Regional and Area Offices
State Fish and Game Departments
University and Research Programs
Herbaria and Museums

Dorothy Allard, Regional Ecologist, The Nature Conservancy
W.T. Olds, Associate Regional Director, Fish and Wildlife Enhancement, U.S. Fish and Wildlife Service

Great Plains Habitat Region: *Great Plains and Prairies*



Geographical Description of the Region

The Great Plains Habitat Region, *Great Plains and Prairies*, contains parts of 10 states. The region includes parts of North Dakota, South Dakota, Montana, Wyoming, Colorado, Nebraska, Kansas, Oklahoma, New Mexico, and Texas. Parts of EPA Regions 6, 7, and 8 are included. The accompanying map indicates the boundaries of this habitat region and the states it comprises.

The *Great Plains and Prairies* comprises 14 ecoregions (Omernik 1987). The vegetation of the region includes a range of grama, needlegrass, wheatgrass, Nebraska sand hills prairie, bluestem, buffalo grass, indiangrass, bluestem prairie (bluestem, panic, indiangrass), cross timbers (oak, bluestem), mosaic (bluestem, oak, hickory), Blackland prairies of wheatgrass, fescue, sandsage, juniper, oak savanna, mesquite acacia, and savanna bristlegrass. The land use patterns comprise croplands, croplands with grazing lands, cropland with pastures, subhumid grasslands, and semi-arid grazing lands, irrigated agriculture, woodlands, forests, and open woodlands grazed.

Habitats of Concern

The *Great Plains and Prairies* contains many habitats of concern, of which the most obvious fall into four general categories: riparian habitats, prairies, brushland, and wetlands. The principal habitats of concern most at risk in the *Great Plains and Prairies* are listed below.

PRINCIPAL HABITATS OF CONCERN
IN THE *GREAT PLAINS AND PRAIRIES*

1. Riparian habitats
   - hardwood draws

2. Prairies
   - tallgrass prairie remnants in Kansas
   - short and midgrass prairie (North Dakota, South Dakota, Colorado, Nebraska, Kansas)
   - Texas blackland prairie and other types

3. South Texas brushlands

4. Wetlands
   - prairie potholes (Montana, North Dakota, South Dakota)

Habitat Values and Trends

The term "rangeland" describes the lands with climate or soil conditions unsuitable for tree growth. Rangeland comprises nearly a billion ac (34% of land area) in the United States, including some of the world's most productive rangeland (Box 1989).

Grasslands

The *Great Plains and Prairies* contain 78 million ac of rangeland (USDA Forest Service 1989), including both the true prairie (tallgrass) and plains grassland (shortgrass). Tallgrass prairie is dominated by bluestem grasses and includes prairie potholes important for waterfowl breeding. Most of the original tallgrass prairie was plowed under, and the remaining areas were invaded by trees following fire suppression. The largest existing area of tallgrass prairie (1.5 million ha) covers the Flints Hills of Kansas and the Osage Hill of Oklahoma. Plains grassland is dominated by short warm-season grasses of blue grama and buffalo grass and supports pronghorn, mule deer, white-tailed deer, jackrabbit, prairie dog, greater prairie chicken, and sharptailed grouse. The decline of the long-billed curlew is associated with the decrease in this habitat.

About 84% of mammal species and 74% of avian species are associated with rangeland ecosystems during at least part of the year. Thirty-eight percent of the nation's fish species and 58% of the amphibians are represented in the relatively arid rangeland ecosystems (Flather and Hoekstra 1979).

Based on 1984 maps, the average number of endangered and threatened species per county is 3.3 for the *Great Plains and Prairies*. Perhaps the most important habitat for animals in the *Great Plains and Prairies* are riparian areas where the juxtaposition of terrestrial and wetland or aquatic systems enhances the value of the habitat.

By the beginning of the 20th century, the American range was generally overgrazed and depleted. Severe droughts also contributed to the deterioration of rangeland. Although the total area of rangeland has remained relatively constant, the condition of the range ecosystems has varied considerably with competition by livestock for forage and other factors. Cattle, sheep, and wild horses and burros have contributed to reduced forage and to changes in vegetation composition on the majority of U.S. rangelands. Many native prairie types have been lost to overgrazing or agricultural conversion. The loss of grassland habitat has been responsible for declines in many bird populations. The mixed prairie or shortgrass prairie is subject to drought, grasshoppers and jackrabbit attacks, and cacti invasion. However, native shortgrasses are outstanding in their resistance to grazing (perhaps developed in response to grazing by bison) and have shown remarkable improvement in certain areas. An increase in rangeland area in the Great Plains of 11 million ac is predicted for the next 50 years as a result of the natural succession of agricultural land in the Conservation Reserve Program (Joyce 1989). Rangeland in Texas and Oklahoma will likely increase by 14 million ac or 11% during this period.

Texas Habitats

Within the *Great Plains and Prairies*, Texas contains a greater variety of habitats than any other state. However, virtually all of the blackland and tallgrass prairie, coastal bottomlands, and low hills in Texas have been converted to farms, cities, and suburbs (Loftis 1991). Less than 1% of blackland prairie remains in north-central Texas. In the Lower Rio Grande Valley, there remains less than 2% of the native scrubby, hot delta that once was nearly as rich in wildlife as the Everglades. In particular, duck populations have declined, bird variety in the valley has decreased, and the ancient gene pools of blackland prairie plants are being lost. Brushlands in south Texas still support endangered cats (jaguarundi and ocelot) and numerous subtropical bird species. Past brush clearing activities have greatly impacted this habitat, although the U.S. Fish and Wildlife Service is currently preserving and restoring brush habitat in the Lower Rio Grand Valley.

Within Texas the greatest loss of natural vegetation has occurred in the state's High Plains and Blackland Prairies regions. The following describes the status of the natural regions of Texas within the *Great Plains and Prairies* (Loftis 1991):

- High Plains - Lost the buffalo and pronghorn with conversion to cattle and crops. Damming of rivers has eliminated the willow and cottonwood and replaced them with the Old World exotics, salt cedar, and Russian olive.

- Rolling Plains - Low hills and broad flats with headwaters of major rivers. Native grasses have been cleared and replaced with mesquite, snakeweed, and prickly pear.

- Edwards Plateau - Limestone hills, springs, and rivers support endangered wildlife; ranches and big cities compete with wildlife for ground water.

- Cross-Timbers and Prairies - Strips of prairie crossed by oak forests have been changed by farming and urban development.

- Blackland Prairies - Originally 12 million ac, the tallgrasses, big bluestem, Indiangrass, little bluestem and gammagrass are near extinction at 5,000 ac.

- Post Oak Savannah - Nearly all of original grasslands have been plowed under or invaded by thickets.

- Rio Grande Plain - Open grasslands have been converted to thorn forest by overgrazing, and less than 1% of the natural habitat remains.

Riparian Areas

Riparian areas in the *Great Plains and Prairies* constitute perhaps the region's most important habitat type. Although they represent only 2% to 4% of the land area in the United States, they make up 80% of the wildlife habitat. It has been demonstrated that most endangered species require riparian areas (Johnson 1989). Many neotropical migrants also rely on western riparian areas as critical nesting sites. The value of riparian habitat extends at least 0.25 miles into adjacent areas and can support a density of pairs of breeding birds up to 1,000 per 100 ac (Carothers and Johnson 1975).

Riparian areas provide habitat for more species of birds than all other western rangeland vegetation types combined (Chaney et al. 1990). Although riparian areas cover less than 1% of the West, they also serve important ecosystem functions (Gillis 1991). They keep watersheds healthy by storing and releasing water from spring runoff of snowmelt and summer storms, and by providing watering holes for wildlife as well as cattle. They filter sediment and aid floodplain development, improve floodwater retention and groundwater recharge, develop plant root masses that stabilize streambanks, develop channel characteristics that provide appropriate habitat for fish, and support greater biodiversity.

The linear nature of riparian areas contributes to their value (Gregory et al. 1991). River valleys connect montane headwaters with lowland habitats, and provide for the transfer of water, nutrients, sediment, particulate organic matter, and organisms. Riparian areas transfer these materials laterally onto floodplains and create complex mosaics of landforms and heterogeneous ecosystems. Wildlife utilize riparian areas for food, cover, nesting, and rearing of young. Riparian habitats are frequently used by wildlife as migration routes (Thomas et al. 1978). The greater heterogeneity of vegetation in unaltered riparian habitat increases the available ecological niches and increases the number of species that can be supported.

Johnson (1978) estimates that only 10% of the original riparian habitat in United States remains, and that 6% is lost annually. In the Great Plains, less than 1% of land is riparian vegetation (Crouch 1978). Major losses resulted from drainage for conversion to agriculture; other causes include channelization for navigation and flood control, flooding caused by dam construction, and diversion of streamflow for irrigation. Alterations include grazing, timber harvesting, road construction, mining, and other impacts.

Wetlands

Specific national wetland problèm areas identified by Tiner (1984) in the *Great Plains and Prairies* include the following:

- The emergent wetlands of the Prairie Pothole Region.
- Wetlands of the Nebraska Sandhills and Rainwater Basin.

The drainage of inland marshes for range and agriculture has been the greatest in the prairies of the Dakotas and Minnesota, the sandhills of Nebraska, and the Florida Everglades. In Texas, wetlands covering 8.4 million ac or 52% of the original extent have been lost. One-third loss of this loss (296,132 ac) has been in the playa lake complexes that are especially important for waterfowl and migratory species. In general, emergent wetlands have high priority in this region owing to their functional importance and the constant threat of degradation.

Activities and Impacts Affecting Habitats

IMPACTS ON HABITATS OF CONCERN IN THE *GREAT PLAINS AND PRAIRIES*				
	Land Conversion	Timber Harvesting	Grazing	Water Management
Riparian habitats	Residential development and construction of pipeline and transportation corridors	Minor	Sever overgrazing and physical habitat degradation	Impacts of damming and water diversions
Prairies	Conversion to agriculture	None	Severe overgrazing	Moderate
Brushlands	Conversion to urban uses	None	Minor	Minor
Wetlands	Conversion to agriculture and urban uses	None	Minor	Major

The *Great Plains and Prairies* rangeland areas are at risk principally from grazing and water management projects. Dam construction in the Platte River area has also been a major source of modification to terrestrial habitat in that area. Of special concern are the remnants of the tallgrass prairie ecosystem, which has suffered extensive conversion. The rarest of all North America's major biomes, only 10% of the original 142 million ac of tallgrass remains. Much of the 10% represents fragments of old railway rights-of-way, pioneer cemeteries, and various preserves. This prairie habitat is at risk from human encroachment and cattle grazing.

This region is experiencing rapid population growth as part of the westward migration. Highway construction, in particular, has expanded and is creating substantial cumulative impacts on natural areas. The Texas hill country is being rapidly converted to urban uses. Riparian areas are being degraded through overgrazing, and prairie potholes are being converted to agriculture. Although the region has a relatively small population, urban areas such as Denver, CO, and central Texas are experiencing rapid growth while second-home and time-share development is occurring in previously pristine areas (e.g., Montana, Flathead Mountains in Wyoming, and Colorado prairie river systems).

Grazing and water projects especially threaten riparian environments throughout the region. For example, overgrazing and phreatophyte control are destroying riparian vegetation. Water diversions have caused major losses of riparian and wetland habitats and are contributing to the declines of waterfowl along the Mississippi Flyway.

Land Conversion

To date, the most fertile soils within the *Great Plains and Prairies* have been converted to croplands; these same areas have historically supported the greatest abundance of wildlife (Mayer and Laudenslayer 1988). In addition, urban development has been a major source of rangeland conversions. Pressure on local governments to convert open space to residential, commercial, and industrial uses to accommodate growth has been intense, and will continue to destroy rangeland habitats where population growth is most pronounced.

Conversion of rangelands to cropland will increase with the availability of ground water for irrigation (USDA Forest Service 1989). In particular, sandy rangeland in Texas, Colorado, New Mexico, and Nebraska has been converted to farmland (Sheridan 1981). Abandonment of these farms can lead to desertification if the ground water has been depleted. Areas of concern for desertification include Kiowa and Crowley Counties in Colorado. In these semiarid lands, land conversion to agriculture, grazing, and water management can cause groundwater overdraft, salinization of topsoil and water, reduction of surface water, high soil erosion, and destruction of native vegetation.

As with forest habitats, the spatial pattern and fragmentation of rangeland vegetation can negatively affect native fauna and ecosystem health. The loss of grassland habitat to agriculture is responsible for the decline in prairie birds, especially those requiring large continuous habitats, and is analogous to the reduction in old-growth forests and the decline in its obligate species. The upland sandpiper, bobolink, dickcissel, grasshopper sparrow, savannah sparrow, and Henslow's sparrow all declined by 90% between the 1950s and 1970s (Graber and Graber 1983).

Agricultural Impacts

The intensive use of agricultural land in certain areas of the *Great Plains and Prairies* pose additional stresses to habitats through cultivation and irrigation practices (NRC 1982). The use of fertilizers and pesticides, irrigation and drainage, double cropping and increased field size all contribute to increased pollutant loads and severe impacts on habitats. Agricultural chemicals are toxic to many species and can negatively affect population levels, community composition, and ecosystem dynamics. Other intensive cultivation practices directly reduce important hedgerow and riparian habitat and usually produce severe offsite impacts.

Grazing

Widespread devastation of rangeland resulted from uncontrolled overgrazing between 1880 and 1935, and the damage was amplified by the drought years of the 1930s (Branson 1985). The enactment of the Taylor Grazing Act of 1934 reduced grazing pressure at that time. With the advancement of range management science and the moist years following 1960, considerable improvement occurred in range vegetation. However, the USDA Forest Service (1989) reports that 21% of its rangelands are still in "unsatisfactory" condition. The Bureau of Land Management (1989) reports that BLM rangeland condition is 33% good or better, 38% fair, and 13% poor.

The management of public land grazing is shared between the land management agency and the grazing permittee. Grazing permits are issued, and allotments are inspected for use, condition, and compliance by the management agency; actual management of the livestock and maintenance of improvements is the responsibility of the permittee. Attempts to reduce grazing allotments in national forests to allow improvements on lands in poor or fair condition has caused resentment among graziers. However, federal permit fees are only one-fifth the rate for private lands. As private grasslands continue to decline in acreage as a result of urban and agricultural conversion, there will be increased pressure on public lands.

Grazing poses the following threats to rangeland habitats (Cooperrider 1990):

- Competition with ungulates and small herbivores (e.g., desert tortoise) and limits on the populations of free-roaming pronghorn antelope, mule deer, elk, and bighorn sheep.
- Transmission of disease (e.g., dramatic diebacks in bighorn sheep with domestic sheep grazing).
- Loss of cover for birds.
- Spread of exotics and noxious weeds.
- Desertification, or serious degradation.
- The conversion of lands with sagebrush and pinyon-juniper to reseeded grassland for more forage.

Riparian Areas

The most severe impact in terms of supporting healthy ecosystems and native faunas on rangelands has been the loss of 70% to 90% of riparian areas to human activities (Ohmart and Anderson 1986). Losses of riparian areas have caused the endangerment of habitat-dependent species and likely will cause the extirpation of many species if the last remaining areas of individual habitat types are lost (e.g., 10 species may go extinct if the cottonwood-willow association disappears). Johnson (1978) estimates that 6% of riparian areas continue to be lost annually through water management activity, grazing, sand and gravel extraction, and development activities.

On average, the riparian zone is only 2% of a grazing allotment, but it produces 20% of the forage, and the cattle consume 80% of their forage from these riparian areas. Stream bottoms are natural concentration areas for livestock seeking succulent forage, shade, reliable water supply, and favorable microclimate. Only when access is limited by steep slopes are livestock absent from unfenced riparian areas. Grazing impacts riparian areas both by removing vegetation and by trampling. By affecting the spacing of plants, width of the riparian corridor, seedling establishment, and species composition, floristic diversity is often lower in grazed areas. Trampling increases soil compaction, erodes streambanks, decreases water quality, widens and shallows channels, and physically destroys vegetation (Kauffman and Krueger 1984). Riparian degradation causes accelerated runoff and erosion of downcut streambeds, lowered water tables, and desertification of the land. It has a negative impact on wildlife habitats and leads to declines in willows and native grasses. In addition, degraded riparian areas are more susceptible to upland inputs as healthy riparian areas can filter out upland degradation. While the condition of all rangelands has improved since 1980, riparian areas are in their worst historical condition.

Although the values and functions of riparian areas have been widely and severely impacted by cultivation, road building, mining, urbanization, logging, and damming of rivers, grazing has caused the most geographically extensive impacts (Chaney et al. 1990). Impacts of grazing on riparian areas include the following:

- Little vegetation to stabilize streambank and shade stream.
- Lowered water table and subsurface water storage.
- Reduced or absent summer flow.
- Warm water in summer and icing in winter.
- Poor habitat for fish and aquatics.
- Poor habitat for wildlife.
- Reduced amount and quality of forage.

Water Management

The regulation and damming of streams are often performed to control flooding and drain land, resulting in the impoverishment of riparian vegetation (Szaro 1991). Dams and water diversion significantly change downstream flow regimes, levels of winter floodwater, dry-season flow rates, and riparian-zone soil moisture. Downstream areas lose pulse-stimulated responses, while upstream areas are affected by water impoundment and salt accumulation. Native riparian plants are usually unable to colonize the shore of reservoirs because of the altered hydrologic regime. For example, high water levels are maintained much longer in reservoirs than in rivers and streams; changes in the level are more drastic; and the large winter/spring floods required for alluvial seedbeds (e.g., cottonwood) are eliminated.

Mitigations of Impacts

The conservation of habitats requires consideration of mitigations for the major activities impacting habitats of concern. In the *Great Plains and Prairies*, the primary habitat impacts are caused by the following:

- Land conversion of riparian and wetland habitats.
- Grazing of riparian areas.
- Water management impacts of diversion and damming on riparian and wetland areas.

It is likely that certain areas will see additional conversions to cropland or pasture, and that more open ranges will be fenced and thus restrict winter grazing by native ungulates. Increased irrigation will likely follow higher demand for water and adversely affect water tables and stream flow on rangelands. These and other activities will pose a complex of interrelated effects on habitats of concern and will require a holistic, ecosystem-level approach to mitigation. The effects of future management and mitigations on riparian areas will have the greatest impact on wildlife and native ecosystem health (NRC 1982).

Land Conversion

Effective mitigation of land conversion activities can sometimes be obtained only by avoiding impacts on rare or unusual habitat types. Rarely, if ever, is restoration or compensation an adequate mitigation for the loss of these habitats. In these cases, mitigation is a siting issue, where construction and degrading activities are located a distance from the habitats of concern. The habitat is adequately preserved if all possible impact scenarios are accounted for. Barring this solution, effective management measures must be implemented to ensure the protection of the habitats of concern.

In the case of unique riparian or wetland habitats, hydrological and contamination concerns are especially important. Construction or resource management activities require the use of sediment filter strips and other means of intercepting offsite contaminants. Road building and structural "improvements" must not result in altered hydrological regimes. Where rare plant types exist or where habitats are unstable, recreational access may have to be limited. These mitigations can be best implemented by creation of a regional land-use plan (through a coordinating council like the Waterfowl Flyway Council) and landowner incentives (like the Conservation Reserve Program).

Conversion to agricultural land is a special concern in rangelands with increasing irrigation potential. Land conversion to agriculture can cause groundwater overdraft, salinization of topsoil and water, reduction of surface water, high soil erosion, and destruction of native vegetation. Mitigations include more conservative irrigation techniques and improved drainage systems. Soil conservation techniques vary from windbreaks to contour plowing, stripcropping, rotation of crops, conversion to grass, and/or minimum tillage.

Grazing

Future management of grazing on rangelands will determine whether range conditions worsen or improve from their currently degraded state (NRC 1982). In the past, range condition has been estimated by (1) forage production relative to a mythical average, and (2) production of livestock. Recently, some range managers have begun to base condition estimates on deviation from an ideal range or ecological climax. These and other improvements in range science provide for consideration of objectives beyond livestock production. For example, the widely used model of E.J. Dyksterhuis (1949) is based on reversible and gradual community change and is now viewed as inaccurate, as it does not incorporate threshold community shifts (Jahn 1991). The problem for habitat conservation is that the proportion of rangeland climax habitats has greatly decreased, similar to the case with old-growth forest. Although there remain disagreements over proper management methods, it is anticipated that more effective use of ecological analyses of range condition will improve the management of rangelands.

Specific methods of mitigating grazing impacts on rangelands include the following (Branson 1985):

- Proper intensity and season of grazing.
- Practices that improve livestock distribution.
- Control of undesirable species using fire or other appropriate methods.
- Land-surface modification to retain soil moisture for forage production.
- Ecologically based management plans for each site using adequate field data.

Proper grazing management can restore the long-term productivity of most rangelands, but obstacles are grazing tradition, the geographical extent of problem, and the difference between short-term costs and long-term benefits. Successful management requires that traditional intensive measures to increase forage be replaced by different management practices. For example, rest-rotation grazing can improve range conditions, while intensified chemical use and mechanical brush removal to improve forage will likely further degrade range habitats. Certainly, successful rangeland mitigation requires time, flexibility, commitment by graziers, and monitoring and evaluation.

Improvements in the condition of riparian areas will provide the greatest proportional benefit to rangeland integrity and functioning. Szaro (1991) argues strongly for an overall ecosystem approach to research and management of riparian areas. This includes the use of reference sites, a watershed (ecosystem) scale approach, and long time scale considerations (greater than 5 years). Mitigation must consider the following factors:

- Riparian floristic (plant species) diversity should take precedence over structural diversity (vegetation layers and patches) as descriptors of the habitat.

- Wildlife species depend both on floristic composition and on the relationship of riparian areas to animal movement patterns and migratory pathways.

- The distribution of riparian vegetative communities varies with topography and depends principally on elevation.

- Flooding and other natural disturbances are important to riparian systems. They contribute to their status as distinct and highly integrated pockets within other communities.

Successful riparian management requires unique solutions to the specific condition at each site (Chaney et al. 1990). However, general principles include the following:

- Include riparian areas in separate pastures with separate objectives and strategies.
- Fence or herd stock out of riparian areas to let vegetation recover.
- Control the timing of grazing (1) to keep the stock off streambanks that are most vulnerable to erosion, and (2) to coincide with the physiological needs of plants.
- Provide more rest to the grazing cycle to increase plant vigor or to encourage more desirable species.
- Limit grazing intensity.
- Change from cattle to sheep to get better animal distribution through herding.
- Permanently exclude livestock from high-risk and poor recovery areas.

Wetlands

Mitigation of wetlands destruction and degradation is the subject of a growing literature (Kusler and Kentula 1989). Restoration and mitigation banking concepts are still being evaluated as effective mitigation measures for direct wetlands alterations.

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4. Minimize fragmentation of habitat and promote connectivity of natural areas.

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Finally, the reviewer should consider the proposed activities and mitigations in the context of relevant regional program goals and objectives (e.g., whether the outcome of the project will be in accordance with principles set out by regional planning commissions).

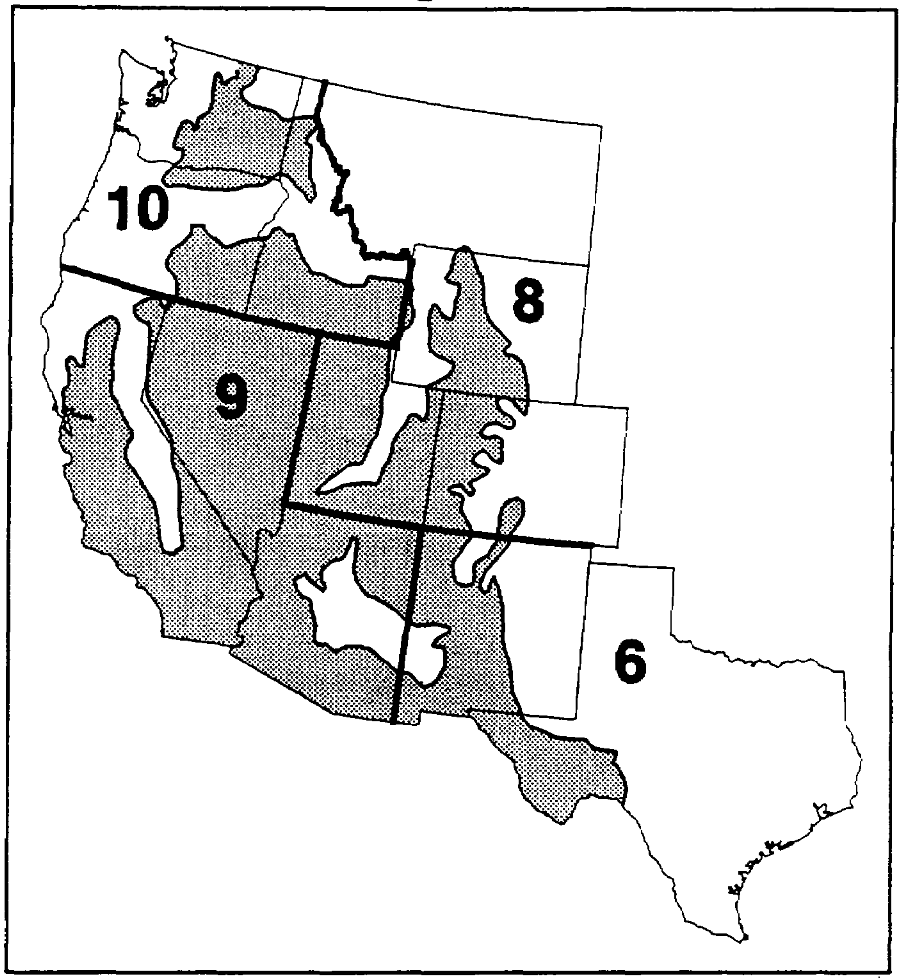
Contacts and Information Sources

When considering habitat conservation issues in an environmental impact assessment for the *Great Plains and Prairies*, the reviewer should consult the following organizations and individuals for information on habitat impacts and mitigations:

State Natural Heritage Programs
U.S. Fish and Wildlife Service, Regional and Area Offices
State Fish and Game Departments
University and Research Programs
Herbaria and Museums

Patrick Bourgeron, Regional Ecologist, The Nature Conservancy
Robert Jacobsen, Regional Associate Director, Fish and Wildlife Enhancement, U.S. Fish and Wildlife Service

Western Rangelands Habitat Region: ***Western Deserts and Grasslands***



Geographical Description of the Region

The Western Rangelands Habitat Region, *Western Deserts and Grasslands*, contains parts of 12 states. The region includes parts of Texas, New Mexico, Arizona, California, Nevada, Utah, Colorado, Wyoming, Idaho, Montana, Oregon, and Washington. Parts of EPA Regions 6, 8, 9, and 10 are included. The accompanying map indicates the boundaries of this habitat region and the states it comprises.

The *Western Deserts and Grasslands* comprises 11 ecoregions (Omernik, 1987). The natural vegetation included in the Region consists of a variety of sagebrush steppe (sagebrush and wheatgrass), saltbush, greasewood, creosote bush, bur sage, needlegrass shrub steppe, juniper, pinyon woodlands, blackbush, Great Basin sagebrush, grama, tobosa shrub steppe, Trans-Pecos shrub savanna (tarbush, creosote), chaparral (manzanita, ceanothus, chamise), and tule marshes (bulrush and cattails). The land use pattern is mostly desert shrublands both grazed and ungrazed, irrigated agriculture, open woodlands grazed, subhumid grasslands, semi-arid grazing lands, forests and woodlands mostly ungrazed, and croplands with grazing land.

Habitats of Concern

The *Western Deserts and Grasslands* contains many habitats of concern, of which the most obvious fall into five general categories: riparian habitats, wetlands, desert complexes and scrub habitats, grasslands, and forested habitats. The principal habitats of concern most at risk in the *Western Deserts and Grasslands* are listed below.

PRINCIPAL HABITATS OF CONCERN
IN THE *WESTERN DESERTS AND GRASSLANDS*

1. Riparian habitats

2. Wetlands
   - shallow emergent wetlands in pluvial lake basins
   - cold desert and steppe in Great Basin and Intermountain regions
   - saline desert wetlands

3. Desert complexes and scrub habitats
   - Sonoran and Mojave desert communities
   - sagebrush type
   - salt desert shrub type

4. Grasslands
   - mixed prairie or shortgrass prairie
   - California grassland
   - Palouse grassland of the Northwest
   - southwest semidesert grassland

5. Forested habitats
   - pinyon-juniper woodland
   - ponderosa pine-bunchgrass type
   - chaparral vegetation of Arizona and California

Habitat Values and Trends

The term "rangeland" describes the lands with climate or soil conditions unsuitable for tree growth. Rangelands encompass nearly a billion ac (34% of land area) in the United States, including some of the world's most productive rangeland (Box 1989). *Western Deserts and Grasslands* habitats traverse the entire range of life zones from the alpine communities of high mountains to the subtropical Sonoran Desert scrub plains and valley of the lower Gila and Colorado Rivers. In the Rocky Mountain region, rangelands (including pinyon-juniper and chaparral-mountain scrub forests) comprise about 336 million ac. Sagebrush alone constitutes the second largest habitat type in United States with 105 million ac, while other habitats include southwestern shrubsteppe, desert shrub, mountain grasslands, mountain meadows, desert grasslands, and plains grasslands. Rangelands in the Pacific States total 68 million ac with 23 million ac in grassland and 45 million ac in shrubland (USDA Forest Service 1989).

By the beginning of the 20th century the American range was generally overgrazed and depleted. Severe droughts also contributed to the deterioration of rangeland. The majority of rangeland is in the West, where declines in area have been minor--4% in the Rocky Mountains and 5% in the Pacific States (USDA Forest Service 1989). Although the total area of rangeland has remained relatively constant, the condition of the range ecosystems has varied considerably with competition by livestock for forage and other factors. Cattle, sheep, and wild horses and burros have contributed to reduced forage and to changes in vegetation composition on the majority of U.S. rangelands. Many native prairie types have been lost to overgrazing or agricultural conversion. Grazing and fire suppression have allowed brush species to replace many of the grass forage species on 200 million ac of the Southwest (National Association of Conservation Districts 1979), negatively impacting bighorn sheep, pronghorn, sage grouse, masked bobwhite quail, and northern aplomado falcon. At the same time, range management activities (such as pinyon-juniper removal, exotic species plantings, predator and native ungulate control) and development along valleys and lower slopes have affected wildlife community composition and critical winter range for wild ungulates. The loss of grassland habitat has been responsible for declines in many bird populations.

No data exist on the extent of areal changes, but the range of pinyon-juniper has certainly increased since settlement as a result of overgrazing, fire suppression, and climate changes. Projections for the next 50 years indicate that rangeland area will increase by 7 million ac in the Rocky Mountains and 3 million ac in the Pacific States as a result of conversion of agricultural lands through the Conservation Reserve Program (USDA Forest Service 1989). However, even where there have been increases in total area, the condition of these rangelands has been severely degraded. The majority of rangeland on nonfederal and Bureau of Land Management lands is in fair to poor condition (Joyce 1989). In the 11 western states, range conditions on public lands are rated as 2% excellent, 29% good, 42% fair, and 26% poor (Wald and Alberswerth 1989).

Klopatek et al. (1979) demonstrated that the tule marsh ecosystem in California, Nevada, and Utah has suffered the greatest loss of any habitat since presettlement times (89%), primarily owing to agricultural conversion. However, in general, vegetation in the western United States has exhibited the least losses due to land conversion and suffer primarily from degradation. Alpine meadows and barrens have undergone the least change because of their rugged topographical setting. In contrast, riparian areas are especially important to wildlife, and losses of this type of vegetation to human activities are estimated at 70% to 90% (Swift and Barclay 1980). In Texas, important rangelands include the rocky landscape along the Big Bend in the Trans Pecos Region and the extremely diverse Mountains and Basins Region, where overgrazing has damaged most of the desert grasslands and small streams (Loftis 1991).

About 84% of mammal species and 74% of avian species are associated with rangeland ecosystems during at least part of the year, and 38% of the nation's fish species and 58% of the amphibians are represented in the relatively arid rangeland ecosystems (Flather and Hoekstra 1989). Based on 1984 maps, the average number of endangered and threatened species per county is 6.1 for the *Western Deserts and Grasslands*, the highest in the nation. Although most of the value placed on rangeland habitats centers on the grass and shrub vegetation existing under different climatic conditions, and the grazing fauna they support, many other values such as reclusive reptile species and the characteristic cryptogamic crusts of the desert are being recognized. Perhaps most important are riparian areas where the juxtaposition of terrestrial and wetland or aquatic systems enhances the value of the habitat.

Woodland and Shrubland

Pinyon-juniper woodland is a widely distributed vegetation type that supports mule deer, mountain lion, coyote, bobcat, jackrabbit, and numerous birds. Pinyon-woodland has invaded grassland areas owing to lack of fire, seed spread by livestock, overgrazing and reduced competition from grasses, and shifts in climate (Branson 1985). Woodland invasion of big sagebrush has occurred more slowly, usually where pinyon-juniper is often adjacent to sagebrush on the dissections of western basins and mountains. Fire management in now being used to encourage the reestablishment of natural vegetation and native diversity in these areas.

In Arizona and California, chaparral vegetation consists of dense stands of evergreen shrubby vegetation. In California, the sparse herbaceous understory of chaparral is less affected by livestock grazing than grasslands, but alien herbaceous species have largely replaced native perennials in both systems (Branson 1985). Areas in Arizona with high grass were converted to dense chaparral with intensive grazing following mineral prospecting in 1890; other chaparral in the Sierra Nevada is a subclimax of forest maintained by frequent fires. This habitat provides watershed protection and critical habitat for the California condor.

Grasslands

Mountain grasslands provide critical winter range for big game. These mountain meadows are sensitive to abuse, as some are destroyed by roads and camping as well as grazing. Desert grasslands consist of blue and black grama grasses and invading shrubs resulting from increased livestock grazing, climatic change, increased competition among plant species, rabbits and rodents, and fire control. They support pronghorn and collared peccary.

The mixed prairie or shortgrass prairie is subject to drought, grasshopper and jackrabbit attack, and cacti invasion. Native shortgrasses are outstanding in their resistance to grazing (perhaps developed in response to grazing by bison) and have shown remarkable improvement in certain areas.

Nowhere else in the West has the native vegetation been as completely replaced as in the 30-million-ac extent of grasslands in California (Branson 1985). Native perennials were largely replaced by introduced Mediterranean annuals by the 1860s, so that now less than 5% of the current species are perennials. This has been attributed to past overgrazing or perhaps fire. Most of the open grassland in the Sacramento and San Joaquin Valleys is now cultivated or in urban or industrial use. Adjacent grass-woodland and chaparral are grazed by livestock.

The Palouse grassland of the Northwest is dominated by bluebunch wheatgrass on 12 million ha of the Columbia Basin Province of Oregon, Washington, and Montana. Because few ungulates were present before the introduction of domestic stock, native grass species were not resistent to grazing and were strongly impacted by livestock grazing and the invasion of Mediterranean annuals (Branson 1985). The most fertile areas have been cultivated, including some drier lands now irrigated. Grazing is now much reduced in the Palouse grassland, and some improvement in range conditions has occurred.

The widespread change of southwestern semidesert grassland to shrubland is one of the greatest modifications of vegetation on western rangelands. Cited causes include excessive use by domestic stock and the reduction of range fires; the loss of topsoil may prevent ever restoring the original grasslands (Branson 1985). Over the last 100 years, mesquite, creosote bush, and tarbush have expanded to cover the entire range.

Deserts

Four major deserts occur in the western United States: the Sonoran, Mojave, Chihuahuan, and Great Basin Deserts. Among desert habitats, the desert riparian and palm oasis habitats support the greatest number and densities of bird species (Mayer and Laudenslayer 1988). The Sonoran and Mojave Deserts, in particular, support unusual plant and animal communities that are threatened by increased human activities in these regions. Cold desert types of the Great Basin support mule deer, pronghorn, coyote, collared peccary, and feral horses. Hot desert shrublands support desert mule deer, collared peccary, antelope, and desert bighorn sheep.

Both decreased rainfall in this century and effects of grazing have impacted the widely spaced woody plants and cacti of the Sonoran Desert, including the cessation of reproduction in saguaro cactus. The Mojave Desert is suffering degradation from offroad vehicles, which resulted in the cessation of the annual Barstow to Vegas motorcross (The Washington Post 1990). Desert habitats in general support many populations of unique and endangered species, including the desert tortoise. Unique geomorphological features such as desert buttes and the Utah salt flats are also facing threats from recreational activity, air pollution, and water withdrawal (Lancaster 1991).

The sagebrush habitat type is unusually susceptible to change when grazed. Many bunchgrasses in the sagebrush type lack resistance, and the historical response has been the following: (1) an increase in native shrubs undesirable for browsing, (2) reduction in grasses and forbs, and (3) exploitation of voids by alien annual weeds adapted to heavy grazing. A history of grazing and cultivation has led to encroachment and takeover by annual grasses, primarily cheatgrass. Mitigation includes burning of annuals but is effective only where there is sufficient annual precipitation. The success of cheatgrass has facilitated the successful introduction of exotic chukar partridge and supports the majority of wild horse and burro herds. The sagebrush types also support sage grouse, pronghorn, and mule deer. It is likely that the original sagebrush habitat can never be restored to pristine conditions even with removal of domestic animals (Branson 1985).

The salt desert shrub type is often called the shadescale zone because of its sparse vegetation and usually widely spaced shrubs with essentially no understory or interstitial species. In general, where there is an understory (such as black sage), historical overgrazing has reduced grasses and promoted shrub growth and invasion by the exotics halogeton and Russian thistle.

Riparian Areas

Riparian areas in the West constitute perhaps the region's most important habitat type. Although they represent only 2% to 4% of the land area in the United States, they make up 80% of the wildlife habitat. It has been demonstrated that most endangered species require riparian areas (Johnson 1989). Many neotropical migrants also rely on western riparian areas as critical nesting sites. The value of riparian habitat extends at least 0.25 miles into adjacent areas and can support a density of pairs of breeding birds up to 1,000 per 100 ac (Carothers and Johnson 1975).

Riparian areas provide habitat for more species of birds than all other western rangeland vegetation types combined (Chaney et al. 1990). Within the Great Basin of southeastern Oregon and in southeastern Wyoming, more than 75% of terrestrial wildlife species depend on riparian systems. In Arizona and New Mexico, 80% of all vertebrates use them for at least half of their life cycle and more than 40% of the species are totally dependent on riparian areas. Although riparian areas cover less than 1% of the West, they also serve important ecosystem functions (Gillis 1991). They keep watersheds healthy by storing and releasing water from spring runoff of snowmelt and summer storms and by providing watering holes for wildlife as well as cattle. They filter sediment and aid floodplain development, improve floodwater retention and groundwater recharge, develop plant root masses that stabilize streambanks, develop channel characteristics that provide appropriate habitat for fish, and support greater biodiversity.

The linear nature of riparian areas contributes to their value (Gregory et al. 1991). River valleys connect montane headwaters with lowland habitats, and provide for the transfer of water, nutrients, sediment, particulate organic matter, and organisms. Riparian areas transfer these materials laterally onto floodplains and create complex mosaics of landforms and heterogeneous ecosystems. Wildlife utilize riparian areas for food, cover, nesting, and rearing of young. Riparian habitats are frequently used by wildlife as migration routes (Thomas et al. 1978). The greater heterogeneity of vegetation in unaltered riparian habitat increases the available ecological niches and increases the number of species that can be supported.

Of the 175 million ac of floodplains along streams and rivers in the conterminous United States, 20% are considered to be rangeland (Johnson 1978). Valley trenching starting in the 1880s resulted in the loss of many riparian meadows through massive sheet and rill erosion. The introduction and spread of saltcedar, or tamarisk, became common in most drainages in the Southwest after 1920. Saltcedar displaces native vegetation upon which certain species depend; it reduces the diversity of native shrubs and cottonwoods and transpires large quantities of water. Attempts to increase water yields by reduction of phreatophytes (such as saltcedar) have included root plows, dozer blades, various mowers and choppers, and chemical spraying. These treatments have declined significantly in recent years as a result of concerns about their efficacy and environmental impact.

Johnson (1978) estimates that only 10% of the original riparian habitat in United States remains, and that 6% is lost annually. Major losses resulted from drainage for conversion to agriculture; other causes include channelization for navigation and flood control, flooding caused by dam construction, and diversion of streamflow for irrigation. Alterations include grazing, timbering, road construction, mining, and other impacts. In Arizona, 95% of the woody riparian habitat has been lost or degraded since pre-settlement. In Utah, settlement patterns saw riparian areas converted to farmland, frequently hay fields. They continue to be threatened by water management activity, grazing, sand and gravel extraction, and development activities.

Wetlands

Specific western wetland problem areas identified by Tiner (1984) include the following:

- Estuarine wetlands of the U.S. Coastal Zone.
- Western riparian wetlands.

Wetlands in the Western Great Basin and Intermountain regions include riparian wetlands and shallow wetlands in pluvial lake basins. These shallow wetlands are often saline or alkaline as a result of high evaporation. Important large wetlands include the Bear River Marshes, UT, Malheur Lake Marshes, OR, Stillwater Marsh in the Carson Sink, NV, Tule-Klamath Basin in CA and OR, and the marsh systems of the California central valleys. Nesting habitat for Canada geese has been lost as much of the marshlands of the Great Salt Lake have been inundated with rising lake level (Thomas 1990). Important coastal estuary habitats include the large Gulf of California estuary and the fringing marshes along San Diego and Tomales Bays.

Aquatic Systems

The water area in *Western Grasslands and Deserts* is generally restricted to large bodies of water such as the Great Salt Lake (one-third of all water in the region), and the upper Missouri, Snake, and Colorado River systems.

Activities and Impacts Affecting Habitats

The *Western Deserts and Grasslands* has suffered extensive degradation and loss of rangelands through conversion to cropland; urban expansion; domestic and feral equine competition with indigenous populations for range resources; grazing-pressure effects from the introduction of shrub species to grasslands; and range management activities, including the use of herbicides and the exclusion of natural inhabitants (U.S. Forest Service 1989). Other activities negatively affecting rangelands include water management projects that dam or divert water supplies, mining impacts, and the use of remote rangelands as targets for waste disposal.

For example, in California more than 17 million ac of natural habitat have been lost through conversion to urban and agricultural land, including nearly 90% of riparian habitats in the Central Valley (California DFFP 1988). Major habitats that have lost significant acreages in the last 30 years include grasslands and coastal scrub. The use of grasslands for grazing also results in habitat loss and fragmentation, including excessive surface soil erosion on nearly 25% of western rangelands.

Grazing and water projects especially threaten riparian environments throughout the region. For example, overgrazing and phreatophyte control are destroying riparian vegetation in Arizona and New Mexico. Water diversions in the Central Valley and elsewhere have caused major losses of riparian and wetland habitats and are contributing to the declines of waterfowl along the Pacific Flyway.

Recreational use of off-road vehicles and military maneuvers are also degrading arid environments such as the Mojave. By one calculation, more than a half million ac have been disturbed by motor vehicles in California (California DFFP 1988). Fragile coastal dune habitats have also been damaged and eliminated by development, recreation, and introduced species.

The following activities result in the major impacts on habitats of concern in the *Western Grasslands and Deserts.*

IMPACTS ON HABITATS OF CONCERN IN THE *WESTERN GRASSLANDS AND DESERTS*					
	Land Conversion	Grazing	Mining	Water Management	Other
Riparian habitats	Residential development and construction of pipeline and transportation corridors	Degradation from domestic and feral ungulates	Moderate	Historical impact of impoundments and water diversions	Recreational use
Wetlands	Agricultural conversion	Moderate	Moderate	Historical impact of impoundments and water diversions	Minor
Deserts	Urban expansion	Degradation from domestic and feral ungulates	Moderate	Major impact of water diversions	Off-road vehicle use
Grasslands	Agricultural conversion	Degradation from domestic and feral ungulates	Minor	Minor	Minor
Woodlands and shrublands	Urban expansion	Moderate	Minor	Minor	Moderate

Land Conversion

To date, the most fertile soils within the *Western Grasslands and Deserts* have been converted to croplands; these same areas have historically supported the greatest abundance of wildlife (Mayer and Laudenslayer 1988). In addition, urban development has been a major source of rangeland conversions, reaching the highest urban densities at lower elevations with the majority of cities of 10,000 in population occupying areas formerly in grassland or scrub vegetation.

Urban and suburban expansion have converted large areas around the Los Angeles metropolitan area. In addition, some of California's fastest growing areas are in rural counties, including those with significant range resources. Rapid growth from the Sunbelt migration is now occurring around Las Vegas and other desert cities. In the Las Vegas area, the expansion of housing development has been facilitated by land trades with the Bureau of Land Management. Riparian areas in particular are under heavy pressure from development in New Mexico, Arizona, and Nevada. Pressure upon the land and local governments to convert open space to residential, commercial, and industrial uses to accommodate growth has been intense, and will continue to destroy rangeland habitats where population growth is most pronounced.

Conversion of rangelands to cropland will increase with the availability of ground water for irrigation (USDA Forest Service 1989). For example, sandy rangeland in Texas, Colorado, New Mexico, and Nebraska has already been converted to farmland (Sheridan 1981). Abandonment of these farms can lead to desertification if the ground water has been depleted. Areas of concern for desertification include the Challis Planning Unit in Idaho, the San Jaoquin Basin in California, the Gila, Santa Cruz, and San Pedro River Basins in Arizona, and the Sonoran and Chihuahuan Deserts in Southwest. In these arid and semiarid lands, land conversion to agriculture, grazing, and water management can cause groundwater overdraft, salinization of topsoil and water, reduction of surface water, high soil erosion, and destruction of native vegetation. Irrigation can also have adverse impacts on rangelands when poor drainage leads to waterlogged areas.

As with forest habitats, the spatial pattern and fragmentation of rangeland vegetation can negatively affect native fauna and ecosystem health. The loss of grassland habitat to agriculture is responsible for the decline in prairie birds, especially those requiring large continuous habitats, and is analogous to the reduction in old-growth forests and its obligate species. The upland sandpiper, bobolink, dickcissel, grasshopper sparrow, savannah sparrow, and Henslow's sparrow all declined by 90% between the 1950s and 1970s (Graber and Graber 1983).

Agricultural Impacts

The intensive use of agricultural land in certain areas of the *Western Grasslands and Deserts* poses additional stresses to habitats through cultivation and irrigation practices (NRC 1982). The use of fertilizers and pesticides, irrigation and drainage, double cropping, and increased field size all contribute to increased pollutant loads and severe impacts on habitats. Agricultural chemicals are toxic to many species and can negatively affect population levels, community composition, and ecosystem dynamics. Intensive cultivation practices (e.g., cotton agriculture in deserts) usually produce severe offsite impacts.

Grazing

Widespread devastation of rangeland resulted from uncontrolled overgrazing between 1880 and 1935, and the damage was undoubtedly amplified by the drought years of the 1930s (Branson 1985). The enactment of the Taylor Grazing Act of 1934 reduced grazing pressure at that time. With the advancement of range management science and the moist years following 1960, considerable improvement occurred in range vegetation. However, the USDA Forest Service (1989) reports 21% of its rangelands were still in "unsatisfactory" condition. The Bureau of Land Management (1989) reports that rangeland condition is 33% good or better, 38% fair, and 13% poor.

Overstocking and overgrazing have historically resulted in severe degradation and catastrophic flooding of rangelands. Undesirable and irreversible changes include replacement of grassland with creosote bush in the arid Southwest; replacement of native perennial bunchgrasses by Mediterranean annuals in California grasslands; and conversion of native vegetation in the Great Basin to an artificial balance of grasses and shrubs. Many national forest lands now contain different rangeland communities (e.g., invasion by Utah juniper into grass-shrub and replacement of grasses by big sagebrush).

The management of public land grazing is shared between the land management agency and the grazing permittee. Grazing permits are issued and allotments inspected for use, condition, and compliance by the management agency; actual management of the livestock and maintenance of improvements is the responsibility of the permittee. Attempts to reduce grazing allotments in national forests to allow improvements on lands in poor or fair condition has caused resentment among graziers. However, federal permit fees are only one-fifth the rate for private lands. As the acreage of private grasslands continues to decline with urban and agricultural conversion, there will be increased pressure on public lands.

Grazing poses the following threats to rangeland habitats (Cooperrider 1990):

- Competition with ungulates and small herbivores (e.g., desert tortoise) and limits on the populations of free-roaming pronghorn antelope, mule deer, elk, and bighorn sheep.
- Transmission of disease (e.g., dramatic diebacks in bighorn sheep with domestic sheep grazing).
- Loss of cover for birds.
- Spread of exotics and noxious weeds.
- Desertification, or serious degradation.
- The conversion of lands with sagebrush and pinyon-juniper to reseeded grassland for more forage.

Riparian Areas

The most severe impact in terms of supporting healthy ecosystems and native faunas on rangelands has been the loss of 70% to 90% of riparian areas to human activities (Ohmart and Anderson 1986). Losses of riparian areas have caused the endangerment of habitat-dependent species such as the Least Bell's vireo and likely will cause the extirpation of many species if the last remaining areas of individual types are lost (e.g., 10 species may become extinct if the cottonwood-willow association disappears). Johnson (1978) estimates that 6% of riparian areas continues to be lost annually. Historical loss estimates include 98% of riparian habitats in the Sacramento Valley of California, 95% in Arizona, and 90 to 95% in the Rocky Mountains Region. In Utah, settlement patterns saw riparian areas converted to farmland, frequently hay fields. They continue to be threatened by water management activity, grazing, sand and gravel extraction, and development activities.

Grazing is so ubiquitous in riparian ecosystems of the Southwest that only a few ungrazed sites exist (Szaro 1991). On average, the riparian zone is only 2% of a grazing allotment, but it produces 20% of the forage, and the cattle consume 80% of their forage from these riparian areas. Stream bottoms are natural concentration areas for livestock seeking succulent forage, shade, reliable water supply, and favorable microclimate. Only when access is limited by steep slopes are livestock absent from unfenced riparian areas. Grazing impacts riparian areas both by removing vegetation and by trampling. By affecting the spacing of plants, width of the riparian corridor, seedling establishment, and species composition, floristic diversity is often lower in grazed areas. Trampling increases soil compaction, erodes streambanks, decreases water quality, widens and shallows channels, and physically destroys vegetation (Kauffman and Krueger 1984). Riparian degradation causes accelerated runoff and erosion, downcut streambeds, lowered water tables, and desertification of the land. It has a negative impact on wildlife habitats and leads to declines in willows and native grasses. In addition, degraded riparian areas are more susceptible to upland inputs as healthy riparian areas can filter out upland degradation. While the condition of all rangelands has improved since 1980, riparian areas are in their worst historical condition.

Although the values and functions of riparian areas have been widely and severely impacted by cultivation, road building, mining, urbanization, logging, and damming of rivers, grazing has caused the most geographically extensive impacts (Chaney et al. 1990). Impacts of grazing on riparian areas include the following:

- Little vegetation to stabilize streambank and shade stream.
- Lowered water table and subsurface water storage.
- Reduced or absent summer flow.
- Warm water in summer and icing in winter.
- Poor habitat for fish and aquatics.
- Poor habitat for wildlife.
- Reduced amount and quality of forage.

Mining

Surface mining has severely degraded large areas of the *Western Grasslands and Deserts*. Surface deposits of minerals are extracted by removing successive layers of the terrestrial environment. Reclamation efforts have increased, but true restoration success is especially difficult in arid habitats. Establishment of vegetation is problematic even with fast growing nonnative species. Oil and gas development also pose severe risks to the pristine natural areas of the West. Exploration and production of both land and off-shore oil reserves are in direct conflict with many wildlife requirements. The substantial infrastructure required by mining activities also contributes to habitat degradation.

Water Management

The regulation and damming of streams are often performed to control flooding and drain land, resulting in the impoverishment of riparian vegetation (Szaro 1991). Dams and water diversion significantly change downstream flow regimes, levels of winter floodwater, dry-season flow rates, and riparian-zone soil moisture. Downstream areas lose pulse-stimulated responses while upstream areas are affected by water impoundment and salt accumulation. Native riparian plants are usually unable to colonize the shore of reservoirs because of the altered hydrologic regime. For example, high water levels are maintained much longer in reservoirs than in rivers and streams; changes in the level are more drastic; and the large winter/spring floods required for alluvial seedbeds (e.g., cottonwood) are eliminated.

Recreational Activities

The characteristics of riparian areas that attract wildlife and livestock also attract human recreation such as birdwatching, hiking, fishing, camping, hunting, trapping, picnicking, floating, boating, and river running (Carothers and Johnson 1975). These activities are increasing as leisure time, personal income, mobility, and pollution levels increase in the western United States. This will place even greater stress on these rare and abused ecosystems.

<u>Military Activities</u>

The large number of military training areas located in the *Western Grasslands and Deserts* results in major impacts on arid land environments. Both a reduction in vegetative ground cover and changes in species composition result from tracked vehicle activity and troop maneuvers (Diersing et al. 1992). There is a major shift from perennial warm-season grass (blue grama) to invading annual cool-season grasses following disturbance by tracked vehicles. This activity can also reduce densities of shrubs, trees, and succulent plants; the loss of juniper can exceed its ability to regrow.

Mitigations of Impacts

The conservation of habitats requires consideration of mitigations for the major activities impacting habitats of concern. In the *Western Deserts and Grasslands*, the primary habitat impacts are caused by the following:

- Grazing of riparian areas.
- Land conversion of riparian and wetland habitats.
- Urban conversion of desert and shrubland habitats.
- Mining impacts on arid lands.
- Water management impacts of diversion and damming on riparian and wetland areas.

It is likely that certain areas will see additional conversions to cropland or pasture, and that more open ranges will be fenced and thus restrict winter grazing by native ungulates. Increased irrigation will likely follow higher demand for water and adversely affect water tables and stream flow on rangelands. These and other activities will pose a complex of interrelated effects on habitats of concern and will require a holistic, ecosystem-level approach to mitigation. The effects of future management and mitigations on riparian areas will have the greatest impact on wildlife and native ecosystem health (NRC 1982).

<u>Grazing</u>

Future management of grazing on rangelands will determine whether range conditions worsen or improve from their currently degraded state (NRC 1982). In the past, range condition has been estimated by (1) forage production relative to a mythical average, and (2) production of livestock. Recently, some range managers have begun to base range condition on deviation from an ideal range or ecological climax. This and other improvements in range science provide for consideration of objectives beyond livestock production. For example, the widely used model of E.J. Dyksterhuis (1949) is based on reversible and gradual community change and is now viewed as inaccurate, as it does not incorporate threshold community shifts (Jahn 1991). The problem for habitat conservation is that the proportion of rangeland climax habitats has greatly decreased, similar to the case with old-growth forest. Although there remain disagreements over proper management methods, more effective use of ecological analyses of range condition will likely improve the management of rangelands.

Specific methods of mitigating grazing impacts on rangelands include the following (Branson 1985):

- Proper intensity an season of grazing.
- Practices that improve livestock distribution.
- Control of undesirable species using fire or other appropriate methods.
- Land-surface modification to retain soil moisture for forage production.
- Ecologically based management plans for each site using adequate field data.

Proper grazing management can restore the long-term productivity of most rangelands, but obstacles are grazing tradition, geographical extent of problem, and the difference between short-term costs and long-term benefits. Successful management requires that traditional intensive measures to increase forage be replaced by different management practices. For example, rest-rotation grazing can improve range conditions, while intensified chemical use and mechanical brush removal to improve forage will likely further degrade range habitats. In addition, fire can be used as a management tool to return pinyon-juniper areas to their previous savannah condition. As a rule, conversion to cattle from sheep requires more management as cattle use bottomland more intensely than sheep. Therefore, summer cattle use of desert ranges in an undesirable practice. Successful rangeland mitigation requires time, flexibility, commitment by graziers, and monitoring and evaluation.

Improvements in the condition of riparian areas will provide the greatest proportional benefit to rangeland integrity and functioning. The Bureau of Land Management (BLM) has plans for restoring 180,000 stream miles within 270 million ac of BLM lands to improve the functioning and status of 23.7 million ac of riparian/wetland systems to meet demands for protecting watersheds, restoring water quality, and enhancing conditions for fish, wildlife, livestock, and outdoor recreation (Jahn 1991).

Szaro (1991) argues strongly for an overall ecosystem approach to research and management of riparian areas. This includes the use of reference sites, a watershed (ecosystem) scale approach, and long time scale considerations (greater than 5 years). Mitigation of impacts to riparian areas should consider the following factors:

- Riparian floristic (plant species) diversity should take precedence over structural diversity (vegetation layers and patches) as descriptors of the habitat.

- Wildlife species depend both on floristic composition and on the relationship of riparian areas to animal movement patterns and migratory pathways.

- The distribution of riparian vegetative communities varies with topography and depends principally on elevation.

- Flooding and other natural disturbances are important to riparian systems. They contribute to their status as distinct and highly integrated pockets within other communities.

Successful riparian management requires unique solutions to the specific condition at each site (Chaney et al. 1990). However, general principles include the following:

- Include riparian areas in separate pastures with separate objectives and strategies.

- Fence or herd stock out of riparian areas to let vegetation recover.

- Control the timing of grazing (1) to keep the stock off streambanks they are most vulnerable to erosion, and (2) to coincide with the physiological needs of plants.

- Provide more rest to the grazing cycle to increase plant vigor or encourage more desirable species.

- Limit grazing intensity.

- Change from cattle to sheep to get better animal distribution through herding.

- Permanently exclude livestock from high-risk and poor-recovery areas.

Land Conversion

Effective mitigation of land conversion activities can sometimes be obtained only by avoiding impacts on rare or unusual habitat types. Rarely, if ever, is restoration or compensation an adequate mitigation for the loss of these habitats. In these cases, mitigation is a siting issue, where construction and degrading activities are located a distance from the habitats of concern. The habitat is adequately preserved if all possible impact scenarios are accounted for. Barring this solution, effective management measures must be implemented to ensure the protection of the habitats of concern.

In the case of unique riparian or wetland habitats, hydrological and contamination concerns are especially important. Construction or resource management activities require the use of sediment filter strips and other means of intercepting offsite contaminants. Road building and structural "improvements" must not result in altered hydrological regimes. Desert habitats are especially vulnerable to mechanical disruption by vehicles and machinery. Where rare plant types exist or where habitats are unstable (e.g., sand dunes), recreational access may have to be limited. These mitigations can be best implemented by creation of a regional land-use plan (through a coordinating council like the Waterfowl Flyway Council) and landowner incentives like the Conservation Reserve Program.

Conversion to agricultural land is a special concern in rangelands with increasing irrigation potential. Land conversion to agriculture can cause groundwater overdraft, salinization of topsoil and water, reduction of surface water, high soil erosion, and destruction of native vegetation. Mitigations include more conservative irrigation techniques and improved drainage systems. Soil conservation techniques vary from windbreaks to contour plowing, stripcropping, rotation of crops, conversion to grass, and/or minimum tillage.

Amelioration of impacts from land conversion to transportation uses requires special mitigation measures. As with all land conversion, the construction of highways and power-line corridors is primarily a siting issue. Avoidance of sensitive habitats may be accomplished by modifications to the route design, and the extent of disturbance can be limited by careful construction practices. However, fragmentation of the larger area is unavoidable in the case of land conversion to transportation corridors. Many structural mitigation measures can be used to lessen the impact on animal movement across transportation routes. Primarily, these include the construction of fences and underpasses. The goal of these structural measures should be to mimic the natural movement and migration patterns of the affected species.

<u>Mining</u>

Mitigation of mining impacts involves siting issues, technological solutions to eliminate contamination, and restoration programs. The major mitigations for oil and gas extraction and production are the proper sitings of rigs, reserve pits, processing facilities, and roads where they will have minimal impacts on habitats of concern. Most important for coal and mineral mining is the siting of mining operations and tailing ponds to avoid habitats of concern, wetlands, riparian areas, and recharge areas. Specific mitigation measures depend on the type of mining and the specific process causing impacts. It is generally best to minimize the area affected as it is unlikely that even the disrupted soils and sediments can be restored. In addition to minimizing the area disturbed, activities should be timed to avoid disturbing nearby plants and animals during crucial periods of their life cycle.

Possible mitigation measures for mining operations include the following (SAIC 1991a, 1991b):

- Design of mine entrances and workings to minimize future mine drainage.
- Runon and runoff control measures such as berms and ditches.
- Adequate depth and lining of pits for containment of muds and leachate.
- Elimination of migration of fluids through casings and dewatering.
- Separation of wastes and contaminated soils with proper disposal.
- Treatment of leach heaps and neutral or acidic wastewaters to reduce the load of cyanide, nitrates, and heavy metals.
- Closure planning that addresses hydrology, geochemical controls, treatment, and restoration.
- Nets or other covers over process ponds.
- Maintenance of an anaerobic environment in the tailing pile during periods of inactivity.
- Secondary containment of tanks and contingency plans for sudden or catastrophic releases.
- Backfilling and sealing of the mine workings during mine reclamation/closure.
- Recycling of process water, smelter slag, and air pollution control dust.
- Monitoring and elimination of discharges to surface water, groundwater, soils, and air.

- Replenishment of surface and ground waters with treated effluents.

- Road closure and reclamation (following recontouring) with revegetation of native species.

Although the reclamation of mined lands is often unsatisfactory for ecological habitat restoration, reforestation with native trees has been demonstrated (Plass 1975) and would serve to reduce the abundance of nest parasitic brown-headed cowbirds and restrict their access to mature forest.

Wetlands

Mitigation of wetlands destruction and degradation is the subject of a growing body of literature (Kusler and Kentula 1989). Restoration and mitigation banking concepts are still being evaluated as effective mitigation measures for direct wetlands alterations.

Military Activities

Mitigation of the impacts of military activities on habitats has only recently received attention. The Army Corps of Engineers' Construction Engineering Research Laboratory in Champaign, IL, is developing a Land Condition-Trend Analysis (LCTA) Program (Diersing et al. 1992) as a comprehensive means of matching military training mission objectives with effective natural resource management. If such a plan is instituted, it is likely that careful coordination of the siting and timing of training operations will dramatically reduce habitat impacts. An awareness of the ecological consequences of specific activities is essential to effective mitigation. The following general mitigation measures apply the primary impacts of military activity.

- Timing and siting of operations - The noise and disturbance associated with aircraft flights and large troop maneuvers cannot be eliminated. However, sensitive environments can be avoided, and operations can be timed to avoid critical nesting and migratory periods.

- Calculation of allowable use for tracked vehicles - Tracked vehicle movements are a major cause of habitat degradation. Vegetation destruction and soil erosion and compaction are the primary impacts. Precise equations can be developed that estimate sustained tracked vehicle use based on physical properties of the environment, vegetative cover, and changes in vegetative cover caused by the passage of tracked vehicles. For example, tracked vehicle use should be restricted to all-weather roads when possible.

- Fire suppression during artillery practice - Fires created by artillery pose a major problem in arid environments. Rapid identification and suppression by helicopter can virtually eliminate the spread of large-scale fires.

Guidelines for Reviewers

Reviewers of environmental impact assessments will find this document useful if they follow the steps laid out in the introduction:

1. Review the status and trends of habitats in the region.

2. Identify the habitats of concern.

3. Link the activities involved with impacts to these habitats of concern.

4. Devise appropriate mitigations for the impacts.

Each reviewer can then determine the adequacy of the environmental impact assessment in question and recommend modifications to enhance its effectiveness.

In identifying the habitats of concern, the reviewer should supplement the information in this document with detailed locational information on the abundance and distribution of habitats within the region of interest, and with any historical information on the extent and quality of these habitats. Most important, the reviewer should characterize the habitats in terms of their ecological values (e.g., use of wooded wetlands by migratory waterfowl).

In considering the links between activities and habitats, the reviewer should look beyond direct impacts to indirect and subtle effects, including cumulative impacts, interactive and synergistic impacts, and scale-dependent impacts (e.g., effects of fragmentation on ecosystem integrity and species home ranges).

In devising possible mitigations, the reviewer should follow the seven principles for habitat mitigation repeated below. The reviewer should also determine whether adequate assurances have been given that the mitigations proposed will be completed.

1. Base mitigation goals and objectives on a landscape-scale analysis that considers the needs of the region.

2. Mimic natural processes and promote native species.

3. Protect rare and ecologically important species and communities.

4. Minimize fragmentation of habitat and promote connectivity of natural areas.

5. Maintain structural diversity of habitats and, where appropriate, species diversity to promote the natural variety of the area.

6. Tailor management to site-specific environmental conditions and to the unique impacts of the specific degrading activity.

7. Monitor for habitat impacts and revise mitigation plans as necessary.

Finally, the reviewer should consider the proposed activities and mitigations in the context of relevant regional program goals and objectives (e.g., whether the outcome of the project will be in accordance with principles set out by regional planning commissions such as those established for southern California).

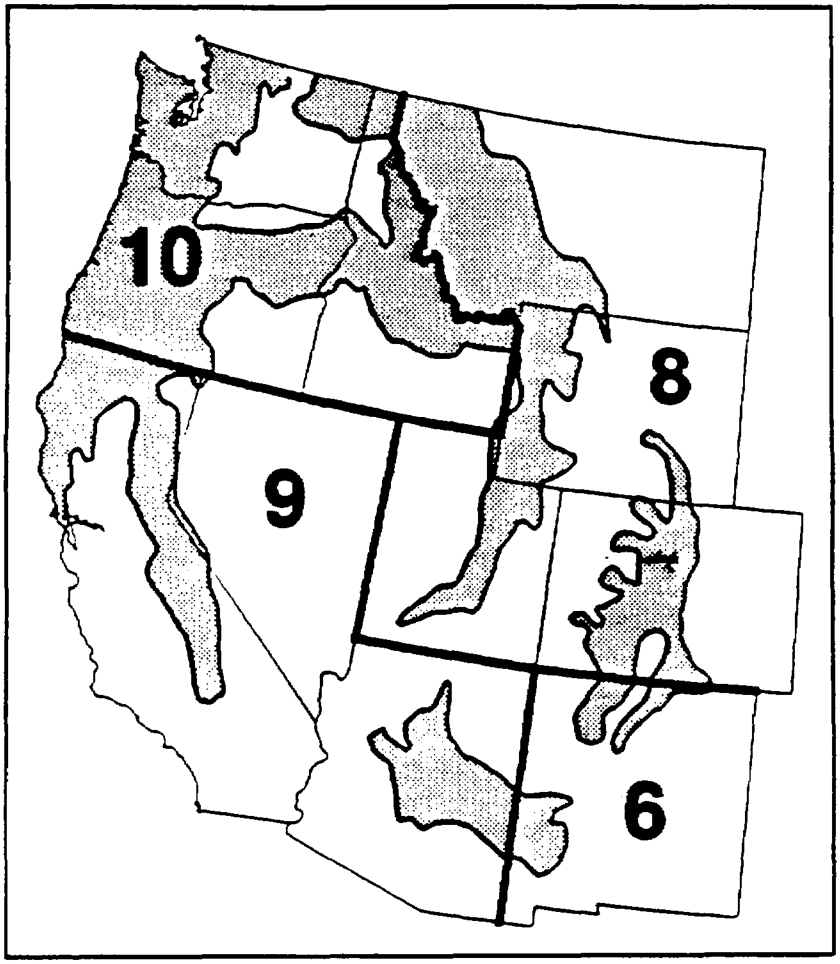
Contacts and Information Sources

When considering habitat conservation issues in an environmental impact assessment for the *Western Deserts and Grasslands*, the reviewer should consult the following organizations and individuals for information on habitat impacts and mitigations:

State Natural Heritage Programs
U.S. Fish and Wildlife Service, Regional and Area Offices
State Fish and Game Departments
University and Research Programs
Herbaria and Museums

Patrick Bourgeron, Regional Ecologist, The Nature Conservancy
R. Langley, Associate Director, Fish and Wildlife Enhancement, U.S. Fish and Wildlife Service

Western Forests Habitat Region: *Western Forests*



Geographical Description of Region

The Western Forests Habitat Region, *Western Forests*, contains parts of 11 states. The region includes parts of Washington, Oregon, California, Arizona, New Mexico, Colorado, Wyoming, Utah, Nevada, Montana, and Idaho. Parts of EPA Regions 6, 8, 9, and 10 are included. The accompanying map indicates the boundaries of this habitat region and the states it comprises.

The *Western Forests* comprises 12 ecoregions (Omernik, 1987). The vegetation of the *Western Forests* includes a wide range of forest types, including spruce, cedar, hemlock, cedar hemlock, Douglas fir, redwood, silver-fir, western spruce, mixed conifer forest (fir, pine, Douglas fir), red fir, lodgepole, subalpine forest, western ponderosa pine, grand-fir, alpine meadows (bent grass, sedge, fescue, needlegrass), Arizona pine, pinyon woodland, Southwestern spruce, and a mosaic of Oregon oakwoods. The land use pattern is predominantly forest and woodlands that are grazed and ungrazed, pasture croplands, and croplands with some interspersion of pasture, woodlands, and forests.

Habitats of Concern

The *Western Forests* contains many habitats of concern; the most obvious fall into four general categories: old-growth conifer forests, remnant hardwood forests, alpine communities, and riparian and aquatic systems. The principal habitats of concern most at risk in the *Western Forests* are listed below.

PRINCIPAL HABITATS OF CONCERN IN THE *WESTERN FORESTS*

1. Old growth conifer forests
   - Douglas fir of Pacific Northwest
   - ponderosa pine east of the Cascades
   - ponderosa pine in Arizona and New Mexico
   - redwood forest in California
   - old growth in northern Rocky Mountains

2. Remnant hardwood forests
   - California oak woodlands
   - Oregon oakwoods

2. Alpine communities
   - montane grasslands
   - alpine talus and barrens

3. Riparian, wetland, and aquatic systems
   - riparian forest
   - salmon fishery habitat

Habitat Values and Trends

The western United States contains a large area of forested land, including the last substantial areas of virgin forest (excluding Alaska). Timber harvesting came to the West with the settlement era after most of the East had already been logged. The three major regions of western forests are the Rocky Mountains, California, and the Pacific Northwest.

Rocky Mountain Forests

In the Middle and Southern Rocky Mountains, intensive exploitation of forest timber began when railroads opened up the region, producing lumber mills in 1870 (Barrett 1980). Fire also played an important role in this region, promoting lodgepole pine at the expense of Douglas fir. Logging came later to the Northern Rocky Mountains, where the forests of Idaho and western Montana represent the largest area of contiguous forest in the United States with more than 80% of the land forested.

Agricultural settlement increased rapidly after the Civil War, reaching into the fertile grasslands and open timbered foothills. Farmland extension is currently slow but continuing into the forest area. About half of the forest area is grazed.

Current forestry efforts are directed at the conversion of old-growth and high-graded stands to commercial timber harvesting. Although white pines forests were intensively logged between 1910 and 1925, old-growth forests still predominate over much of the Northern Rocky Mountain Region. A total of 138 million ac of forest occur in the Rocky Mountain Region, most in pinyon-juniper woodland (47 million ac of dry plateaus and broken tablelands), Douglas-fir (18 million ac), fir-spruce (16 million ac), ponderosa pine (16 million ac), and lodgepole pine (15 million ac) (USDA Forest Service 1989). In recent decades, a modest, steady decline in forest area has occurred as a result of clearing for roads, urban development, powerline rights-of-way, and surface mining. Substantial areas in Montana, Idaho, and Colorado have been converted to homesites. Data indicate that forest ecosystem types that have declined since 1963 include western white pine (89%), larch (35%), lodgepole pine (29%), ponderosa pine (27%), and western hardwood (19%). In the future, forest area is expected to remain stable as timber harvesting lands decrease and conversions to urban uses increase.

The Rocky Mountain region is a highly dissected series of peaks and ridges containing both forests and rangeland (see Western Rangelands Habitat Region). Even within forested areas, many unusual habitats exist, including old-growth spruce/skunk cabbage, acid shale ponderosa pine communities, intermountain bunchgrass, and various alpine and subalpine communities. Many of these are uncommon and isolated, representing especially vulnerable habitats in this region.

California Forests

California is second only to Alaska in total forest area; forest area constitutes 40% of the state, or 40 million ac (Barrett 1980). Since 1953, the total commercial forest area in California has decreased by about 1 million ac because of grazing development, roads, construction of reservoirs and power lines, urban expansion, and park and wilderness dedication. The six major habitat types include redwood, mixed conifer, true fir, ponderosa pine, California oak woodland, and California chaparral. Although the state has a long history of industrial use of forest, efforts are under way to restrict timber harvesting throughout the state.

Losses of forests and woodlands have been less than 1% per year over the last decade and are caused principally by urbanization and construction of roads and reservoirs (USDA Forest Service 1989). However, the condition of forests has been greatly affected by logging, which has reduced the number of trees by 55% and changed open stands of large trees to dense stands of small trees. Forest composition has changed; hardwoods have replaced coastal conifers, while white fir and incense-cedar have replaced pine in the interior. Originally 74% of forest was mature or old growth and 13% was in sapling or saw timber stages. Now nearly 40% of mature stands have been cut and are in the sapling stage. Predictions are that about 11% of timberland will be reserved for mature stands (Raphael et al. 1988). Air pollution, both acid deposition and smog, also have caused extensive damage to these forest ecosystems, especially to the susceptible granitic watersheds and Southern California forests (California Department of Forestry and Fire Protection 1988).

Pacific Northwest Forests

The Pacific States, excluding California, comprise about 50 million ac of forest. Major types include western hemlock-sitka spruce, coastal Douglas fir, true fir-mountain hemlock, mixed conifers of southwestern Oregon, mixed pine-fir of eastern Oregon and Washington, and northwestern ponderosa pine (USDA Forest Service 1989). Since 1963, many forest ecosystem types have declined: western white pine (99%), redwood (31%), ponderosa pine (26%), Douglas fir (20%), and lodgepole pine (17%).

The Pacific Northwest rainforest (principally spruce, hemlock, and fir) constitutes one of the most productive forest regions in the world. The western areas of Washington and Oregon are 80% forested, and the eastern portions of these states are 35% to 40% forested. Large-scale settlement began in the Pacific Northwest during the middle of the 19th century. Agriculture was restricted to river valleys and the steppe vegetation of the East, but adjacent forested areas were used extensively for grazing of both sheep and cattle. Timber harvesting increased with the advent of the California Gold Rush and has continued to be a major industry ever since. Forest use west of the Cascades started along waterways and progressed inland onto steeper slopes as logging technologies improved. Virgin timber is still being cut on the higher slopes of the Olympics and western slopes of the Cascades, but the age classes of the second forest follow the original, regional pattern of harvesting. Clearcut logging has been almost universal west of the Cascades with partial cut logging used to the east (Barrett 1980).

The Olympic Peninsula of Washington contains one of the best examples of old-growth forests remaining in the United States. Of the 390,000 ac of old growth existing in 1940, only 94,000 remained in 1988 (Morrison 1990). Although sitka spruce and western hemlock covered more than 1 million ac before European settlement, logging and human-caused fires have reduced the area by 97%. Additiona' ecological zones include Douglas fir, pacific silver fir, mountain hemlock, subalpine fir, and alpine. In both Oregon and Washington, the most obvious change in forest cover over the last 10 years has been the reduction in area of old-growth forests by logging. Major impacts in both states have been clear cutting, road building, edge effects, fragmentation, and human fires, as well as disease and pest mortality in eastern Washington.

Morrison (1988) assessed the amount and condition of ecological old-growth conifer forest that still exists on 6 of the 12 westside national forests in the coastal region of Oregon, Washington, and northern California and estimated the amount of old growth that will remain in 5 years if present policy continues. The results predict that old growth covers less area and is being lost more rapidly than is claimed by the U.S. Forest Service. Factors contributing to the vulnerability of old-growth forest in the Northwest include the following:

- Nearly all of the old growth on private lands in the Pacific Northwest has been logged.
- Only 31% of the remaining old growth is in designated wilderness areas.

Based on 1984 maps (Flather and Hoekstra 1989), the average number of endangered and threatened species per county is 5.6 for the *Western Forests*, among the highest in the nation. The following listing of Pacific Northwest forest types illustrates some of their characteristic ecological values:

Douglas-fir - dense overstory forest of ancient trees supports important plants such as epiphytes and yew, and rare species such as spotted owl and marbled murrelet; forest openings and early seral stages support elk, grizzly bear, moose, blue and ruffed grouse, mammalian predators such as mountain lions and bobcats, and endangered American peregrine falcon.

Fir-spruce and hemlock-Sitka spruce - dense canopy forest with little understory but interspersed with meadows or stream bottoms with willows and aspens; support moose, elk, wolverine, lynx, black bear, mountain lion, and some grizzly bear.

Ponderosa pine - historically, fire kept habitat open and park-like with ground cover of grasses, sedges, and forbs; supports black bear, mule deer, elk, and mountain lion.

Lodgepole pine - supports moose, elk, wolverine, lynx, black bear, mountain lion, coyote, and some grizzly bear.

Redwood - dense overstory forest of small geographic extent in California and Oregon; supports elk, mountain lion, bobcat, and black bear.

Western hardwoods - 50% or more of coast live oak, canyon live oak, blue oak, valley oak, interior live oak, or aspen; in California supports mule deer, California quail, mountain quail, skunk, and endangered San Joaquin kit fox.

Pinyon-juniper - often adjacent to sagebrush on dissection of western basins and mountains; supports mule deer, mountain lion coyote, bobcat, jackrabbit, numerous birds.

Alpine - above timberline in Rocky Mountain and Pacific Coast regions; consists of grasses, grasslike species and forbs; includes lakes and ponds with endemic trout; supports pika, pocket gopher, yellow-bellied marmot, mule deer, elk, mountain sheep, and ptarmigan.

Riparian and Wetland Areas

The original amount of wetland area in the Rocky Mountain Region has been decreased by one-third since widespread settlement began (Windell et al. 1986). The Rocky Mountains comprise a relatively small area of wetlands, but a wide variety of wetland types, ranging from intermountain basins to alpine tundra. Much of the impact results from the concentration of human population within certain Rocky Mountain areas. Population tends to be sparse in the high plains, heavy along the junction between the plains and mountains, and moderate in the mountains along narrow valley floodplain corridors. The heaviest development is concentrated along water courses.

Development along water courses has dramatically reduced the area of wetlands in the Pacific States. As in the Rocky Mountain Region, many Pacific States wetlands occur in rangeland environments rather than forests. However, many wetlands do occur in the *Western Forests*, including the large estuaries of San Francisco and Puget Sound and the forest wetlands along the north coast of Washington. Perhaps of even greater importance in the *Western Forests* are riparian areas. These forest zones provide essential habitat for many forest species, connect forest to wetland areas, and provide filtering and transport of nutrients for aquatic systems. The traditional use of riparian areas for access to timber harvesting and transport of logs has severely degraded riparian areas in the *Western Forests*.

Aquatic Systems

Approximately 6 million ac of water area occur in the vast Rocky Mountains. About 4 million ac of water area occur in the Pacific States, including coastal waterways such as Puget Sound and Strait of Juan de Fuca, Crater Lake, and rivers such as the Columbia and Willamette. Incomparable salmonid fisheries were once characteristic of the *Western Forests*. Timber harvesting practices and development on major rivers, especially damming for hydropower and irrigation diversion, have dramatically reduced fishery habitat and salmonid abundance.

Activities and Impacts Affecting Habitats

The major sources of degradation and loss to terrestrial environments in the *Western Forests* are timber harvesting practices and mining. Land conversion and water management activities also affect both terrestrial and aquatic systems. The ecologically rich old-growth forests of the Pacific Northwest are under intense logging pressure as private old-growth lands are eliminated. The total area of old growth has declined by 80%, and the remaining forests are being fragmented and degraded. This issue represents one of the country's most intense conflicts of natural area preservation and resource exploitation.

In addition to timber harvesting, mining and oil and gas development pose risks to the pristine natural areas of the Northwest. Gold mining is causing habitat degradation in Washington. Pressure upon local governments to convert open space to residential, commercial, and industrial uses to accommodate growth have been intense, and have also been responsible for the loss of wildlife habitat in the area. Losses have been most severe where the effects of urbanization and population growth are most pronounced. California habitats that have lost significant acreages in the last 30 years include foothill oak woodland, closed-cone pine-cypress, and redwood forests. Much of the development in the next decade will occur on hardwood forest lands of California.

The following activities result in the major impacts on habitats of concern in the *Western Forests.*

IMPACTS ON HABITATS OF CONCERN IN THE *WESTERN FORESTS*				
	Land Conversion	Timber harvesting	Mining	Water Management
Old-growth forests	Minor	Clearcutting and forest fragmentation	Moderate	Minor
Remnant hardwood forests	Urban development	Moderate	Minor	Minor
Alpine communities	Resort and recreational development	Minor	Moderate	Minor
Riparian, wetland, and aquatic systems	Residential development in river bottoms and construction of pipeline and transportation corridors	Major impacts of erosion and sedimentation	Major	Major impacts of damming and water diversion

Timber Harvesting

Old-growth forests are of special concern for habitat conservation. Not only do these sensitive terrestrial environments contain unique assemblages of species but they are also under intense timber harvesting pressure. The only significant remaining area of old-growth forest is the conifer forest of the Pacific Northwest. Less than 5 million ac of the original 15 million ac of old growth in western Washington and western Oregon remain. Some view the altered landscape of the Olympic Peninsula in western Washington due to timber cutting as the most drastic ecological disturbance of the last 10,000 years (Morrison, 1990). Less than 20% of the original old growth on the peninsula remains, and entire ecological associations of plants and animals that once dominated lower elevations on the peninsula are now rare. Ancient forests of the Pacific Northwest have been so fragmented by roads and logging that the viability of the old-growth ecosystem is in question.

Forests serve many important ecosystem functions that can be lost or degraded by timber harvesting practices (Norse 1990a). For example, forests are naturally efficient regulators of water-flow levels through the retention of surface run-off during high precipitation periods and the maintenance of moisture levels during low precipitation periods. Forest stabilization of soils prevents increases in sediment loads and maintains water purity for aquatic habitat and human uses. In the Klamath Mountains of southwestern Oregon, erosion rates in roaded areas averaged more than 100 times higher than on undisturbed sites, and erosion caused by logging alone averaged 6.8 times higher than on undisturbed sites (Dyrness 1975). In northern California over a 9-year period, stream sediment in a developed watershed was more than 80% higher with road building and 275% higher with logging and roads than in a similar, undisturbed watershed. Forests also serve to retain nutrients within the ecosystem by a complex process of litter accumulation ahd decomposition. Logging often destroys the nutrient retention ability of the soils and has been implicated in failures to achieve forest regeneration.

Fragmentation of habitat is another severe impact of timber harvesting on forests. As roads and clearcuts are placed in virgin forest, landscape fragmentation increases and the natural buffering of extremes in temperature, drought, snow pack, and wind decreases. As a result, blowdowns, fires, insect and disease infestations, snag cutting, and salvage logging increase. Approximately 60 ac of old growth are destroyed or altered for each new 25-ac clearcut in unfragmented old growth as a result of deleterious edge effects; for every mile of road built in unfragmented old growth, approximately 97 ac of old-growth forest are altered by edge effects (Morrison 1988).

Land Conversion

Land conversion in the *Western Forests* has the greatest impact on the remnant woodlands at the edge of urban centers and on the forest valleys along river courses. The U.S. Forest Service (1989) projections over the next 50 yr indicate a loss in forest area of 8 million ac with the conversion to urban and developed uses in the Seattle-Tacoma areas, numerous areas in California, and the mixed forest-urban zones of Oregon. Conversion of both uplands and wetlands has a profound effect on the natural communities in the West. In recent years, the expansion of populations into formerly pristine areas is fragmenting forest through industrial and residential development. Rural areas are also suffering from "spin-off development" associated with highway development.

Impacts on Riparian and Wetland Areas

In addition to the conversion of lands along water courses, riparian and wetland areas of the *Western Forests* face threats from other offsite and onsite activities. The primary impacts to wetlands include the following:

- Recreation and other development (especially vacation houses and resort facilities).
- Drainage and filling for buildup and parking areas (impact of cumulative effects).
- Dewatering, diversion, and irrigation (there are many transbasin diversion systems in the Rocky Mountains).
- Forest clear-cutting and channelization (causing erosion, faster snowmelt, reduced water retention, and nutrient loading downstream).
- Mineral mining (aquifer draw down, channelization, stream diversion, acid and alkaline mine drainage, waste disposal sites and tailing areas, erosion and sedimentation).
- Sand and gravel mining (expected to triple or quadruple by the year 2000).

- Road and railroad access (construction of roads, villages, and towns along medium to large streams).

- Dams and reservoirs (decreasing the acreage of riverine, riparian, and wetland systems).

Impacts on Aquatic Systems

Aquatic resources, especially the anadromous fisheries of the Pacific Northwest, are also suffering severe declines. The complex of dams on the Columbia River kill approximately 93% of young salmon and have contributed to the listing of the sockeye and chinook salmon as threatened. Recovery plans for these and other fish species will have large-scale ramifications on water management and human industry planning for the region (Weisskopf 1991).

Mitigations of Impacts

The conservation of habitats requires consideration of mitigations for the major activities impacting habitats of concern. In the *Western Forests*, the primary habitat impacts are caused by the following:

- Timber harvesting and fragmentation of old-growth forests.
- Land conversion of remnant hardwood forests and alpine communities.
- Mining impacts on forests and aquatic systems.
- Water management impacts of diversion and damming on rivers.

Management of the combined effect of these activities on sensitive habitats requires a holistic, ecosystem-level approach. The new interagency efforts to manage the Greater Yellowstone Ecosystem in Montana and Wyoming (approximately 20 million ac, 69% publicly owned by five federal agencies) is the premier example of an integrated approach to ecosystem management (Jahn 1991). In particular, the approach pays special attention to the needs of wide-ranging species such as elk and grizzly bears. It emphasizes the need to look at the landscape scale (not institutional boundaries) for the implications of habitat value and modification.

Timber Harvesting

At a minimum, the production of commercial wood products from an area must not exceed the sustainable level if the ecological integrity of a forested area is to be maintained. Where sensitive forest types exist, logging may be completely prohibited or constrained to specific methods to prevent habitat loss or degradation. In other areas, more extreme harvesting methods may be allowed or prescribed to establish or maintain desired forest conditions. Acceptable methods will vary according to local forest ecology and the desired future condition of the site. Analysis of harvesting techniques must be based upon an analysis of the structure and diversity of the forest canopy, midstory, and understory.

A recent directive of the Chief of the U.S. Forest Service acknowledges this fact and points out that clear cutting is acceptable only when needed to replicate natural ecological processes. Selective cutting can preserve forest structural diversity, the primary determinant of wildlife habitat (Harris et al. 1979). However, it can reduce horizontal diversity (NRC 1982). The harvesting technique employed must be based upon sound silvicultural prescriptions and demonstrate its capability to maintain vertical diversity (foliage height diversity), horizontal diversity (interspersion, edge, juxtaposition, patchiness), and a mixture of live and dead wood. Specific timber harvesting operations should be designed to preserve the structure and diversity of the natural forest habitat.

An important component of selective cutting should be the preservation of standing dead trees. Many forest birds nest, roost, or forage for invertebrates in standing trees with decayed wood. These cull trees are usually the first focus of forest-thinning operations to the detriment of the birds. Breeding bird abundance declines rapidly following a clear cut, and the species composition continues to change for 10 to 15 years (DeGraaf 1991). However, if trees with cavities are saved, many of these species can successfully forage on sound boles. About one large cavity or den tree per 2 ha is required for population of large species such as wood ducks; this requires harvest rotations of 100 to 125 years (although rotations of 65 years produce trees large enough for species nesting in smaller cavities).

Timber harvesting practices modified to reduce the impacts of simplification must also address fragmentation. The setting aside of undisturbed tracts will not achieve viable populations of the larger, wider-ranging species. Some species require specific habitat conditions; others require particular arrangements of several communities. Therefore, a successful faunal conservation strategy must emphasize the landscape configuration, not just the structural content of the communities themselves.

Responding to the "biodiversity crisis," the U.S. Forest Service is moving toward an ecosystem approach to forest management (Bob Szaro, personal communication). Recent forest management plans have incorporated tenets of the "New Forestry" espoused by Jerry Franklin. These progressive plans require the rigorous implementation of ecological management practices to maintain forest productivity and preserve the functioning of sensitive forest components such as old-growth or late-successional forests. Effective mitigations for habitat conservation in forest management require specific management measures at the site, watershed, and landscape levels. For example, the location and size of timber harvests should be planned to minimize reduction of core area of mature forest (e.g., harvest only alternate basins until regrowth). Maintenance of mature-forest stands in managed landscape can be achieved by extending rotation (beyond 80) to 150 to 200 years, by leaving some stands unharvested for old growth, and by linking stands. Landscape-scale considerations include the provision of buffer zones and habitat corridors as discussed in the introduction to this document. Management measures recommended for conserving habitat within managed forests include the following:

- Minimize the construction of new roads and close roads not in use either permanently or seasonally.

- Use best management practices (BMPs) such as filter strips to minimize erosion during harvesting or road construction.

- Maintain 100-ft riparian zones with adjacent feathered transition zones to buffer edge effects.

- Restrict harvesting operations to periods when the ground is either dry or frozen.

- Maintain site productivity by retaining large woody material and minimizing mineral soil exposure and compaction during harvesting.

- Manage for natural disturbance patterns to maintain natural openings and successional-stage composition.

- Maintain connections between blocks of interior forest, especially old growth.

- Provide for the protection of special areas, including cliffs, caves, taluses, riparian areas, and old-growth stands.

- Maintain the structural integrity and the native variety of the forest by managing for the natural composition of the following components: vegetative types, seral stages, tree types and sizes, standing dead trees and down material, tree snags, and cavity trees.

The preservation of old-growth forest in the Pacific Northwest has been the focus of intensive scientific study. For example, the report of The Scientific Panel on Late-Successional Forest Ecosystems provides a model of alternatives of forest management for preservation of ecosystems and wildlife (Johnson et al. 1991). Using the spotted owls as an indicator species, the panel derived the following recommendations for mitigating the impact of timber harvesting on late-successional/old-growth forest in the Northwest:

- Late-Successional/Old-Growth (LS/OG) areas should be protected as habitat conservation areas (HCAs). Blocks suitable to maintain 20 pairs of owl should be not more than 12 miles apart. Areas between these blocks must follow the 50-11-40 rule: 50% of forest must have an average tree diameter of 11 inches and canopy closure of 40%. Areas with additional owls may be added to the HCAs to meet the goal of preservation.

- Provisions for watersheds and fish include major reductions in road mileage and road drainage improvements, as well as extended logging rotations. "Problem" roads would be improved or removed, and unstable soils would remain unroaded.

- Riparian management will include no-harvest areas of varying width (1/4 mi to 50 ft depending on the value of the stream).

In a series of alternatives (from high timber harvest to LS/OG and watershed/fish emphasis), the Panel found that "current forest plans do not provide a high level of assurance for maintaining habitat for old-growth-dependent species." No alternative provides abundant timber harvest and high levels of habitat protection for species associated with late-successional forests.

Land Conversion

Effective mitigation of land conversion activities can sometimes be obtained only by avoiding impacts on rare or unusual habitat types. Rarely, if ever, is restoration or compensation an adequate mitigation for the loss of these habitats. In these cases, mitigation is a siting issue, where construction and degrading activities are located at a distance from the habitats of concern. The habitat is adequately preserved if all possible impact scenarios are accounted for. Barring this solution, effective management measures must be implemented to ensure the protection of the habitats of concern.

In the case of unique woodland or wetland habitats, hydrological and contamination concerns are especially important. Construction or resource management activities require the use of sediment filter strips and other means of intercepting offsite contaminants. Road building and structural "improvements" must not result in altered hydrological regimes. Where rare plant types exist or where habitats are unstable (e.g., riparian areas), recreational access may have to be limited. These mitigations can be best implemented by creation of a regional land-use plan (through a coordinating council like the Waterfowl Flyway Council) and landowner incentives like the Conservation Reserve Program.

<u>Mining</u>

Mitigation of mining impacts involves siting issues, technological solutions to eliminate contamination, and restoration programs. The major mitigations for oil and gas extraction and production are the proper sitings of rigs, reserve pits, processing facilities, and roads where they will have minimal impacts on habitats of concern. Most important for coal and mineral mining is the siting of mining operations and tailing ponds to avoid habitats of concern, wetlands, riparian areas, and recharge areas. Specific mitigation measures depend on the type of mining and the specific process causing impacts. It is generally best to minimize the area affected as it is unlikely that even the disrupted soils and sediments can be restored. In addition to minimizing the area disturbed, activities should be timed to avoid disturbing nearby plants and animals during crucial periods of their life cycle.

Possible mitigation measures for mining operations include the following (SAIC 1991a, 1991b):

- Design of mine entrances and workings to minimize future mine drainage.
- Runon and runoff control measures such as berms and ditches.
- Adequate depth and lining of pits for containment of muds and leachate.
- Elimination of migration of fluids through casings and dewatering.
- Separation of wastes and contaminated soils with proper disposal.
- Treatment of leach heaps and neutral or acidic wastewaters to reduce the load of cyanide, nitrates, and heavy metals.
- Closure planning that addresses hydrology, geochemical controls, treatment, and restoration.
- Nets or other covers over process ponds.
- Maintenance of an anaerobic environment in the tailing pile during periods of inactivity.
- Secondary containment of tanks and contingency plans for sudden or catastrophic releases.
- Backfilling and sealing of the mine workings during mine reclamation/closure.

- Recycling of process water, smelter slag, and air pollution control dust.
- Monitoring and elimination of discharges to surface water, groundwater, soils, and air.
- Replenishment of surface and ground waters with treated effluents.
- Road closure and reclamation (following recontouring) with revegetation of native species.

Although the reclamation of mined lands is often unsatisfactory for ecological habitat restoration, reforestation with native trees has been demonstrated (Plass 1975) and would serve to reduce the abundance of nest parasitic brown-headed cowbirds and restrict their access to mature forest.

Wetlands

Mitigation of wetlands destruction and degradation is the subject of a growing body of literature (Kusler and Kentula 1989). Restoration and mitigation banking concepts are still being evaluated as effective mitigation measures for direct wetlands alterations.

Guidelines for Reviewers

Reviewers of environmental impact assessments will find this document useful if they follow the steps laid out in the introduction:

1. Review the status and trends of habitats in the region.
2. Identify the habitats of concern.
3. Link the activities involved with impacts to these habitats of concern.
4. Devise appropriate mitigations for the impacts.

Each reviewer can then determine the adequacy of the environmental impact assessment in question and recommend modifications to enhance its effectiveness.

In identifying the habitats of concern, the reviewer should supplement the information in this document with detailed locational information on the abundance and distribution of habitats within the region of interest, and with any historical information on the extent and quality of these habitats. Most important, the reviewer should characterize the habitats in terms of their ecological values (e.g., use of wooded wetlands by migratory waterfowl).

In considering the links between activities and habitats, the reviewer should look beyond direct impacts to indirect and subtle effects, including cumulative impacts, interactive and synergistic impacts, and scale-dependent impacts (e.g., effects of fragmentation on ecosystem integrity and species home ranges).

In devising possible mitigations, the reviewer should follow the seven principles for habitat mitigation repeated below. The reviewer should also determine whether adequate assurances have been given that the mitigations proposed will be completed.

1. Base mitigation goals and objectives on a landscape-scale analysis that considers the needs of the region.

2. Mimic natural processes and promote native species.

3. Protect rare and ecologically important species and communities.

4. Minimize fragmentation of habitat and promote connectivity of natural areas.

5. Maintain structural diversity of habitats and, where appropriate, species diversity to promote the natural variety of the area.

6. Tailor management to site-specific environmental conditions and to the unique impacts of the specific degrading activity.

7. Monitor for habitat impacts and revise mitigation plans as necessary.

Finally, the reviewer should consider the proposed activities and mitigations in the context of relevant regional program goals and objectives (e.g., whether the outcome of the project will be in accordance with principles set out by regional planning commissions such as those established for the Columbia River Basin).

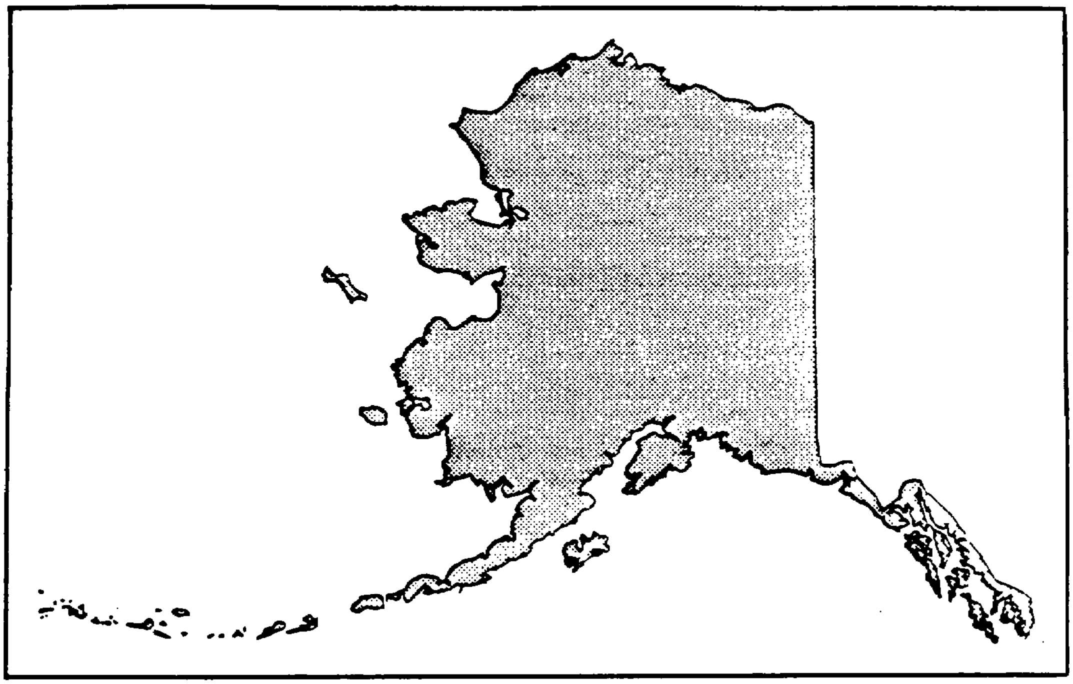
Contacts and Information Sources

When considering habitat conservation issues in an environmental impact assessment for the *Western Forests*, the reviewer should consult the following organizations and individuals for information on habitat impacts and mitigations:

State Natural Heritage Programs
U.S. Fish and Wildlife Service, Regional and Area Offices
State Fish and Game Departments
University and Research Programs
Herbaria and Museums

Patrick Bourgeron, Regional Ecologist, The Nature Conservancy
Jim Teeter, Associate Director, Fish and Wildlife Enhancement, U.S. Fish and Wildlife Service

ALASKA HABITAT REGION: *ALASKA*



Geographical Description of the Region

The Alaska Habitat Region consists of the state of *Alaska* and is contained in EPA Region 10. Although only the single state is included, *Alaska* constitutes one-third of the land area of the United States. Also, because it is separated from the conterminous states, *Alaska* contains a unique set of habitat types.

Alaska comprises 5 ecoregions (Bailey 1980). The vegetation of *Alaska* consists of grasses, sedges, lichens with willow shrubs, birch-lichen woodland, needleleaf forest, cottongrass-tussock, dwarf shrubs, lichens, mosses, dwarf birch, Labrador-tea, cinquefoil, white spruce mixed with cottonwood, balsam poplar, willow rose, dogwood, berry bushes, dwarf arctic birch, crowberry, arctic willow, resin birch, dwarf blueberry, cottongrass, bluejoint, taiga, green and thinleaf alder, dogwood, sphagnum, bog rosemary, white mountain-avens, moss-campion, black oxytrope, arctic sandwort, alder thickets, devils club, mountain ash, and alpine-azalea.

Alaska is unique among the regions of the United States in that it still possesses large areas of pristine landscape. The scale of the state is vast, and changes to the landscape from different land use patterns, although increasing, are still primarily restricted to urban centers, fishing ports, and oil and gas producing operations.

Habitats of Concern

Alaska contains many habitats of concern; the most obvious fall into five general categories: old-growth forest, riparian watersheds and fisheries, tundra, maritime forest, and boreal forest. The principal habitats of concern most at risk in *Alaska* are listed below.

PRINCIPAL HABITATS OF CONCERN IN *ALASKA*

1. Old-growth forest of southeastern Alaska

2. Riparian watersheds and salmon rivers

3. Tundra
   - wetlands (e.g., muskeg and sedge meadow)
   - arctic tundra foothills and uplands
   - alpine tundra

4. Aleutian Island maritime grasslands

5. Boreal forest of south-central Alaska

Habitat Values and Trends

The scale and range of habitat types that occur in *Alaska* are unparalleled in the contiguous United States. Large areas of *Alaska* are still without any ground inventories or meaningful ecological descriptions.

Tundra

Alaska contains 173 million ac of rangeland mostly in arctic and alpine tundra. By many definitions, the tundra of *Alaska* is wetland and includes many wetland complexes such as muskeg and sedge meadow. These areas support large populations of caribou, moose, and about 30,000 reindeer. Also present are bears, wolves, coyotes, foxes, squirrels, and mice. Lichen is a primary ground cover in *Alaska*, and it is critical to the survival of reindeer. Lichen habitat has been seriously degraded by overgrazing and wildfires. In the arctic tundra and Bering tundra provinces, cottongrass-tussock is widespread; in the Brooks Range region, lower elevations may be vegetated with sedges and shrubs (USDA Forest Service 1989).

Tundra provides critical habitat for waterfowl; it also supports fisheries on the lowlands and black-tailed deer on the uplands. In the North Slope foothills, caribou use the uplands for calving and are seasonally dependent on tundra vegetation. The tundra and maritime grasslands of the Aleutian system provide one of the outstanding pristine ecosystems in the United States.

Forests

Alaska is less than 40% forested. Today, Alaskan forests consist of 116 million ac of fir-spruce and 11 million ac of hemlock-Sitka spruce (USDA Forest Service 1989). More than 90% of the commercial coastal forests are still in old growth; however, in the interior more than 50% are in young stands (Barrett 1980). Except in the immediate vicinity of villages, the native Indians made no impact on the coastal forests. However, both aboriginal and modern cultures have altered the interior forest through fire.

The mainland of coastal Alaska and the island archipelago contain one of the largest pristine rainforest and shoreline ecosystems in the world. Of this, 11,600,000 ha fall within the Tongass and Chugach National Forests and the Glacier Bay National Park and Preserve. Southeast Alaska is 46% forested, with the remainder in alpine, permanent snow and ice (including broad piedmont glaciers at the northern tip), or bog (muskeg). This coastal forest type (Sitka spruce-western hemlock) extends westward across south-central Alaska where the state is only 11% forested. Similar to the Pacific Northwest, Alaska old-growth forest is multi-aged with codominants 200 to 250 years of age. However, Alaskan old-growth forest experiences less frequent natural perturbations (such as fire) and contains a greater percentage of total closed-canopy cover. Highly productive old-growth forests usually occur in smaller patches than in the Pacific Northwest and are increasingly fragmented toward their northern range limit. In general, however, Alaskan old-growth forest is abundant owing to the relatively low frequency of catastrophic disturbance (Alaback and Juday 1989). Coastal Alaskan old growth supports Sitka black-tailed deer and other wildlife species.

Alaska Coastal Plain

The Alaska Coastal Plain is one of the last intact arctic ecosystems. It supports caribou, musk-ox, moose, Dall sheep, wolf, arctic fox, brown bear, and 22% of the western arctic population of lesser snow goose. This area is threatened by oil and minerals exploration and development; in many cases land is being leased to oil companies by native corporations (Frazier 1987). Oil drilling in Prudhoe Bay has caused erosion, vehicle damage, heavy dust load' from the road system, and water damming and tundra ponding.

Aquatic Systems

About 16 million ac of *Alaska* is in water area, principally the coastal waterways, the numerous large rivers of the Yukon system, and more than 3 million lakes more than 20 ac in size. *Alaska* possesses the world's most productive salmon fisheries.

Activities and Impacts Affecting Habitats

The following activities result in the major impacts on habitats of concern in *Alaska*.

IMPACTS ON HABITATS OF CONCERN IN *ALASKA*				
	Land Conversion	Timbering	Mining	Other
Old-growth forest	Minor	Heavy logging in the Southeast	Minor	Minor
Riparian watersheds and fisheries	Urban development in river bottoms and development of pipeline and transportation corridors	Major impact from logging practices and sedimentation	Degradation from in-stream placer mining	Minor
Tundra	Conversion around urban centers	None	Impacts of oil and gas production	Impacts of military activities
Maritime grasslands	Minor	None	Minor	Impacts of military activities
Boreal forests	Minor	Moderate	Minor	Minor

Land Conversion

Alaska is experiencing rapid development of certain areas, especially around Anchorage and Fairbanks (Mary Lynn Nation, personal communication). This includes urban sprawl and the building of infrastructure for tourism. Considerable conflicts with wetland fills have arisen because of the extent of tundra wetland. Land conversions include areas for ports and airports infrastructure, and areas for harbors and the shipping industry. Private fish hatcheries and ladders are consuming land in the south-central region, and the fishing industry in Dutch Harbor has converted land for processing and storage operations. One of the greatest threats is posed by transportation corridors; a recent proposal is to open the Dalton Highway (the hauling road to the North Slope) to recreation.

Timber Harvesting

Timbering of Alaska is principally confined to the coastal southeastern area of productive Sitka spruce-hemlock. It ranks with tourism, behind oil production and fisheries, as the state's major industries (USDA Forest Service 1989). Considerable research has been conducted on timbering methods for this area and will likely result in both less national forest area being available for logging and more intensive timbering of the remaining lands. The increase in privately owned forest will likely result in logging and a decreased forest area in certain locations. In particular, the leasing of land through native corporations has resulted in increased logging.

Timbering activities include clear cuts and conversions for roads, antennas, and other operational areas. Severe impacts are also caused by log transfer, staging, and in-water storage. Negative effects include erosion and siltation of salmon fishery habitat and loss of habitat for black-tailed deer.

Mining

In addition to timbering, mining and oil and gas development pose severe risks to the pristine natural areas of *Alaska*. Exploration and production of oil reserves in *Alaska* are in direct conflict with many wildlife requirements. In addition to the production on the Kenai Peninsula oil patches and offshore oil drilling in Cook Inlet, considerable small-scale drilling exploration is conducted in undeveloped areas. Discovery of oil in these regions would require substantial infrastructure development, including pipelines and tankering. New petroleum and liquid natural gas (LNG) pipelines are also proposed.

Gold mining is another cause of habitat degradation in *Alaska*. This includes placer mining and proposed copper leachate facilities. Impacts include the effects of tailings and runoff, especially the contribution to erosion and sedimentation that negatively affect salmon fisheries.

Military Activities

Military operations constitute another activity degrading habitats in *Alaska*. This is most important in the pristine Aleutian maritime grasslands; the fact that these areas are generally inaccessible has prevented virtually all other degradation. Impacts include toxic releases and bulldozing operations causing erosion.

Mitigations of Impacts

The conservation of habitats requires consideration of mitigations for the major activities impacting habitats of concern. In *Alaska*, the primary habitat impacts are caused by the following:

- Timbering of old-growth forests in southeastern Alaska.
- Mining impacts on tundra and aquatic systems.
- Urban expansion and conversion of tundra environments.
- Impacts of logging and development on riparian areas and salmon fisheries.

Management of the combined effect of these activities on sensitive habitats requires a holistic, ecosystem-level approach. In particular, the approach pays special attention to the needs of wide-ranging species such as caribou. It emphasizes the need to look at the landscape scale (not institutional boundaries) for the implications of habitat value and modification.

Timber Harvesting

At a minimum, the production of commercial wood products from an area must not exceed the sustainable level if the ecological integrity of a forested area is to be maintained. Where sensitive forest types exist, logging may be completely prohibited or constrained to specific methods to prevent habitat loss or degradation. In other areas, more extreme harvesting methods may be allowed or prescribed to establish or maintain desired forest conditions. Acceptable methods will vary according to local forest ecology and the desired future condition of the site. Analysis of harvesting techniques must be based upon an analysis of the structure and diversity of the forest canopy, midstory, and understory.

A recent directive of the Chief of the U.S. Forest Service acknowledges this fact and points out that clear cutting is acceptable only when needed to replicate natural ecological processes. Selective cutting can preserve forest structural diversity, the primary determinant of wildlife habitat (Harris et al. 1979). However, it can reduce horizontal diversity (NRC 1982). The harvesting technique employed must be based upon sound silvicultural prescriptions and demonstrate its capability to maintain vertical diversity (foliage height diversity), horizontal diversity (interspersion, edge, juxtaposition, patchiness), and a mixture of live and dead wood. Specific timber harvesting operations should be designed to preserve the structure and diversity of the natural forest habitat.

An important component of selective cutting should be the preservation of standing dead trees. Many birds nest, roost, or forage for invertebrates in standing trees with decayed wood. These cull trees are usually the first focus of forest-thinning operations, to the detriment of the birds. Breeding bird abundance declines rapidly following a clear cut, and the species composition continues to change for 10 to 15 years (DeGraaf 1991). However, if trees with cavities are saved, many of these species can successfully forage on sound boles. About one large cavity or den tree per 2 ha is required for population of large species such as wood ducks; this requires harvest rotations of 100 to 125 years (although rotations of 65 years produce trees large enough for species nesting in smaller cavities).

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- Use best management practices (BMPs) such as filter strips to minimize erosion during harvesting or road construction.
- Maintain 100-ft riparian zones with adjacent feathered transition zones to buffer edge effects.
- Restrict harvesting operations to periods when the ground is either dry or frozen.

- Maintain site productivity by retaining large woody material and minimizing mineral soil exposure and compaction during harvesting.

- Manage for natural disturbance patterns to maintain natural openings and successional-stage composition.

- Maintain connections between blocks of interior forest, especially old growth.

- Provide for the protection of special areas, including cliffs, caves, taluses, riparian areas, and old-growth stands.

- Maintain the structural integrity and the native variety of the forest by managing for the natural composition of the following components: vegetative types, seral stages, tree types and sizes, standing dead trees and down material, tree snags, and cavity trees.

The conservation of old-growth forest presents a special challenge that is currently being addressed in *Alaska*. In southeastern Alaska, the rainforest extends 500 miles long by 100 miles wide across a mosaic of offshore islands. The forest supports Sitka spruce 200 feet tall and 400 years old with a lush undergrowth of evergreen plants, ferns, and mosses. Most of this rainforest is within the confines of the Tongass National Forest and is subject to the multiuse management and timber harvesting of the U.S. Forest Service. Forest series with late successional components in the Tongass include upland, riparian, and beach Sitka spruce, Sitka spruce-western hemlock, mixed conifer, and subalpine mountain hemlock. An old-growth management prescription for the Tongass prepared by a recent workgroup (Samson et al. 1991) included the following requirements: (1) define ecological units; (2) establish a province system that captures representative habitat for dependent species; and (3) recommend the size, shape, and distribution of habitats to maintain viable populations of species. The group recommends that at least one watershed within each province be left intact for wildlife. Timber and timber-wildlife emphasis alternatives were described. The latter requires that forest management in the Tongass include the following:

- Harvest areas from the periphery inward to maintain large continuous blocks.

- Harvest areas so that they are "sloppy" with small patches of green trees, brushy openings, and snags to increase the habitat available through time.

- Provide edges that are "feathered" to reduce vulnerability to windthrow.

- Harvest habitat types in a manner that ensures the continued existence of each type and relative availability of each type.

- Use habitat models for indicator species to prioritize areas to be retained as old-growth wildlife habitat.

Based on population models of ermine, islands of less than 2,000 ac of forest habitat should not be logged. Alternatively, clusters of smaller islands may withstand timbering if species have appropriate dispersal routes.

Mining

Mitigation of mining impacts involves siting issues, technological solutions to eliminate contamination, and restoration programs. The major mitigations for oil and gas extraction and production are the proper sitings of rigs, reserve pits, processing facilities, and roads where they will have minimal impacts on habitats of concern. Most important for coal and mineral mining is the siting of mining operations and tailing ponds to avoid habitats of concern, wetlands, riparian areas, and recharge areas. Specific mitigation measures depend on the type of mining and the specific process causing impacts. It is generally best to minimize the area affected as it is unlikely that even the disrupted soils and sediments can be restored. In addition to minimizing the area disturbed, activities should be timed to avoid disturbing nearby plants and animals during crucial periods of their life cycle.

Possible mitigation measures for mining operations are listed below (SAIC 1991a, 1991b):

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In the case of unique tundra habitats, hydrological and contamination concerns are especially important. Construction or resource management activities must take special precautions to minimize mechanical disturbance of permafrost soils. Road building and structural "improvements" must not result in altered hydrological regimes. Where rare plant types exist or where habitats are unstable, recreational access may have to be limited. These mitigations can be best implemented by creation of a regional land-use plan (through a coordinating council like the Waterfowl Flyway Council) and landowner incentives like the Conservation Reserve Program.

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Mitigation of wetlands destruction and degradation is the subject of a growing body of literature (Kusler and Kentula 1989). Restoration and mitigation banking concepts are still being evaluated as effective mitigation measures for direct wetlands alterations.

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In devising possible mitigations, the reviewer should follow the seven principles for habitat mitigation repeated below. The reviewer also should determine whether adequate assurances have been given that the mitigations proposed will be completed.

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2. Mimic natural processes and promote native species.

3. Protect rare and ecologically important species and communities.

4. Minimize fragmentation of habitat and promote connectivity of natural areas.

5. Maintain structural diversity of habitats and, where appropriate, species diversity to promote the natural variety of the area.

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Finally, the reviewer should consider the proposed activities and mitigations in the context of relevant regional program goals and objectives (e.g., whether the outcome of the project will be in accordance with principles set out by regional planning commissions).

Contacts and Information Sources

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State Natural Heritage Programs
U.S. Fish and Wildlife Service, Regional and Area Offices
State Fish and Game Departments
University and Research Programs
Herbaria and Museums

Gerry Tande, Regional Ecologist, The Nature Conservancy
Mary Lynn Nation, Division of Federal Activities, U.S Fish and Wildlife Service, Alaska

HAWAII AND THE ISLAND TERRITORIES

This section briefly discusses *Hawaii and the Island Territories*. They comprise a relatively small land area, but are sufficiently distinct to require discussion separate from the seven major regions of the United States.

Geographical Description

The Hawaiian Islands and the Pacific Trust Territories of Guam and the Northern Marianas are all included in EPA Region 9. Puerto Rico and the U.S. Virgin Islands are included in EPA Region 2. Hawaii forms its own ecoregion in the Bailey system (1980), a Highland Ecoregion within the Rainforest Division. The island territories have not been classified into ecoregions by either the Bailey or Omernik systems.

The vegetation of the Hawaiian Islands comprises tropical shrubs, dense needleleaf and broadleaf forests, bogs, and moss lichen communities. Because of its isolation, Hawaii contains many endemic species and possesses a fauna and flora unlike that found anywhere else. Although the community compositions are different, the vegetation of the Pacific Trust Islands and Puerto Rico and the Virgin Islands contains many of the same elements of tropical forests and island floras.

Habitats of Concern

The diverse ecosystems of Hawaii can be classified as existing on dry leeward or wet windward areas. Leeward lowlands consist mostly of introduced plants such as kiawe and haole koa in grassland or savanna habitats. Leeward uplands contain evergreen scrublands and forests with exotics such as guava, Java plum, and Christmasberry. Windward evergreen rainforests are dominated by native ohia and koa, and constitute 0.3 of the 1.7 million ac of forest on Hawaii. Above the rainforest on the highest islands of Maui and Hawaii are zones of mountain parklands of koa and mamane, alpine scrub, and alpine tundra (USDA Forest Service 1989).

Of the 150 vegetation types in the Hawaii Natural Heritage classification, more than 50% are rare and nearly all are endemic (Sam Gon, personal communication). Principal habitats of concern include the following:

- Brackish anchialine pools along the shore.
- Coastal and lowland wetlands (below 3000 ft).
- Coastal and lowland forest and shrub ecosystems.
- Upland forest types.
- Wet bog ecosystems within forests.
- Subalpine and alpine zones.

Habitat Values and Trends

All the major ecological zones are represented in the 6,500 sq mi of Hawaiian land mass. More than 10,000 species of plants and animals are endemic to Hawaii. Extinctions of native species began with the arrival of Polynesians 1,500 years ago and accelerated with the arrival of Europeans in the late

1700s, reaching rates thousands of times the natural rate. Of the 140 bird species native to Hawaii, 70 have become extinct and 30 more are endangered. Currently, 37 species of plants in Hawaii are federally listed as endangered and 152 more are expected to be listed in the next 2 years (Hawaii State Department of Land and Natural Resources et al. 1991).

The aboriginal Hawaiians converted most of the land below the 600-meter elevation to agriculture on the eight main islands. Today, nearly two-thirds of Hawaii's original forest cover and 50% of the rainforest have been lost to land conversion for housing, agriculture, and ranching. Ninety percent of the lowland plains dry forests, 61% of the mesic forests, and 42% of the wet forests have been destroyed. The last remnants of Hawaiian coastal plant communities are on the most remote and arid shores. The unique terrestrial environments of Hawaii are also being degraded or lost due to the logging of tropical forests. Hawaii contains 180 terrestrial ecosystems, of which at least 88 ecosystems will be lost within 20 years unless current losses of habitat are addressed (Tangley 1988). Similar histories have befallen the Pacific Trust Territories of Guam and the Northern Marianas and Puerto Rico and the U.S. Virgin Islands. For example, the loss of tropical rainforest to timbering and conversion to agriculture is a major problem in Puerto Rico.

The invasion of non-native species represents the greatest threat to surviving native species and natural communities on all the U.S. islands. The Hawaiian archipelago has lost more than 75% of its original endemic land bird fauna through prehistoric and historic extinctions; the comparable Galapagos archipelago as a whole is not known to have lost a single land bird species (Loope et al. 1988). The absence of native large mammals has left the native fauna and flora vulnerable to the browsing, rooting, and trampling of introduced pigs, goats, cattle, and deer. On Hawaii's 1.4 million ac of rangeland, most native plants have been replaced by introduced perennials. Native Hawaiian birds have suffered from avian malaria spread by introduced mosquitos, and native plants have been smothered by the exotic banana poka. In Guam, the introduced brown tree snake has wiped out 9 of the 11 species of native birds, and Hawaii is now threatened by the repeated reintroduction of this reptile.

Activities and Impacts Affecting Habitats

The majority of forest land remaining in Hawaii is contained within the state forest reserves and conservation districts. These lands are managed principally for watershed and aquifer protection and allow little commercial wood harvesting. However, timbering of native koa and exotic eucalyptus do occur, and logging continues to impact private lands.

A greater threat to forest ecosystems in Hawaii is livestock grazing. Substantial areas of forest continue to be cleared to promote forage growth for cattle ranching (USDA Forest Service 1989). The current tax structure in Hawaii encourages clearing of forest for ranching.

Conversion of lands for urban and resort construction has a major impact on coastal and lowland environments. In addition, growing commercial and residential development contributes to the loss of dry areas subject to fire. This problem is exacerbated on military firing ranges.

Agriculture has long been an important industry on Hawaii, and it continues to impact adjacent terrestrial and aquatic habitats through sedimentation and contamination with pesticides.

The primary threat to *Hawaii and the Island Territories* is alien species. Introduced species contributing to habitat destruction include herbivorous mammals, predaceous ants, dogs, cats, mongoose, alien arthropods, mollusks, and alien plants. Wet ecosystems, in particular, are threatened by invading non-native animals (principally pigs, goats, deer) that disrupt the natural vegetation to the extent that native species are replaced by non-native plants. The invasion of combustible non-native weeds has created a cycle of wildfires that often destroy rare dryland native plants (Hawaii State Department of Land and Natural Resources et al. 1991).

The decline and extinction of many endemic Hawaiian bird species can be attributed to the unprecedented invasion of exotic species. Among exotic birds, more introductions (162) and establishments (between 45 and 67) have occurred in Hawaii than anywhere else in the world (Scott et al. 1986). Today, more than 80 introduced vascular plant species currently pose threats to the native biota in Hawaii. The inadequacy of detection and control has resulted in continuing invasions, and the problem of existing exotics requires constant management or additional losses will result. It is believed that biological methods offer the best hope of extensive long-term control of the most aggressive alien plants in natural systems.

Guidelines for Reviewers

Reviewers of environmental impact assessments for *Hawaii and the Island Territories* should refer to other regional discussions for more detailed information on habitat impacts and their mitigations. The following section outlines the consideration of habitat conservation in the review process:

1. Review the status and trends of habitats in the region.

2. Identify the habitats of concern.

3. Link the activities involved with impacts to these habitats of concern.

4. Devise appropriate mitigations for the impacts.

Each reviewer can then determine the adequacy of the environmental impact assessment in question and recommend modifications to enhance its effectiveness.

In identifying the habitats of concern, the reviewer should supplement the information in this document with detailed locational information on the abundance and distribution of habitats within the region of interest, and with any historical information on the extent and quality of these habitats. Most important, the reviewer should characterize the habitats in terms of their ecological values (e.g., use of wooded wetlands by migratory waterfowl).

In considering the links between activities and habitats, the reviewer should look beyond direct impacts to indirect and subtle effects, including cumulative impacts, interactive and synergistic impacts, and scale-dependent impacts (e.g., effects of fragmentation on ecosystem integrity and species home ranges).

In devising possible mitigations, the reviewer should follow the seven principles for habitat mitigation repeated below. The reviewer should also determine whether adequate assurances have been given that the mitigations proposed will be completed.

1. Base mitigation goals and objectives on a landscape-scale analysis that considers the needs of the region.

2. Mimic natural processes and promote native species.

3. Protect rare and ecologically important species and communities.

4. Minimize fragmentation of habitat and promote connectivity of natural areas.

5. Maintain structural diversity of habitats and, where appropriate, species diversity to promote the natural variety of the area.

6. Tailor management to site-specific environmental conditions and to the unique impacts of the specific degrading activity.

7. Monitor for habitat impacts and revise mitigation plans as necessary.

Finally, the reviewer should consider the proposed activities and mitigations in the context of relevant regional program goals and objectives (e.g., whether the outcome of the project will be in accordance with principles set out by regional planning commissions).

Contacts and Information Sources

When considering habitat conservation issues in an environmental impact assessment for the *Hawaii and the Island Territories*, the reviewer should consult the following organizations and individuals for information on habitat impacts and mitigations:

State Natural Heritage Programs
U.S. Fish and Wildlife Service, Regional and Area Offices
State Fish and Game Departments
University and Research Programs
Herbaria and Museums

Sam Gon, Regional Ecologist, The Nature Conservancy
Jim Teeter, Associate Director, Fish and Wildlife Enhancement, U.S. Fish and Wildlife Service

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