Paper Task Force Recommendations for Purchasing and Using Environmentally Preferable Paper

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The Paper Task Force

Duke University • Environmental Defense Fund
Johnson & Johnson • McDonald's
The Prudential Insurance Company of America • Time Inc.

Final Report

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AUTHORS

Duke University

Paul Brummett
Evelyn Hicks

Environmental Defense Fund

Lauren Blum
Robert Bonnie
Richard A. Denison
Nat Keohane
Annette Mayer-Ilmanen
Jane B. Preyer
John F. Ruston
Melinda Taylor

Johnson & Johnson

Harold J. Capell
Brenda S. Davis
Barbara M. Greer
Anthony A. Herrmann
Peter Turso

McDonald's Corporation

Linda Croft
Bob Langert

The Prudential Insurance Company of America

Joe DeNicola
Steve Ritter

Time Inc.

David J. Refkin
David Rivchin

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Duke University

Dr. Stephen Boyce
Dr. Norman Christensen
Dr. Richard DiGiulio
Stephanie Finn
Dr. Douglas Lober
Dr. Daniel Richter
David Roberson
Dr. Aarne Vesilind
Duke University School of the Environment graduate students:
- Teos Abadia
- Chris Benjamin
- David Cohen
- Jonathan Cosco
- Jason Karas
- Elizabeth McLanahan
- Kerry Mularczyk
- Pamela Niddrie
- Mark Rampolla
- Paul Schinke
- Stewart Tate

Environmental Defense Fund

Maxine Adams
Bob Braverman
Mechelle Evans
Alexandra Haner
Suzanne Hamid
Steven Levitas
Allan Margolin
Diane Minor
Ciara O'Connell
Diane Pataki
Jackie Prince Roberts
Eliza Reed
Karen Roach
Melody Scott
Sandin Wang

Johnson & Johnson

Suzanne Goggin
Bill Hoppes
Jeff Leebaw
Elizabeth Richmond
Karl Schmidt

McDonald's Corporation

Iris Kast
Dave Kouchoukos
Tauquincy Miller
Walt Riker

NationsBank Corporation

Bruce Lawrence
Saundra Neusum

The Prudential Insurance Company of America

Mary Donelik
Rachel Ingber
Paul Lambdin
Marijane Lundt
Bob Zanisnik

Time Inc.

Elaine Alestra
Peter Costiglio
Barry Meinerth
Deane Raley, Jr.

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Bulow, Dr. Jeremy, Stanford University,
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Sheil, Mary, New Jersey Department of Environmental Protection
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Singh, Dr. Paul, Michigan State University, School of Packaging
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Springer, Dr. Allan, Miami University (Ohio), Department of Pulp and Paper Science and Engineering
Stevens, Barbara, Ecodata, Inc.
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Project Synopsis

The Paper Task Force

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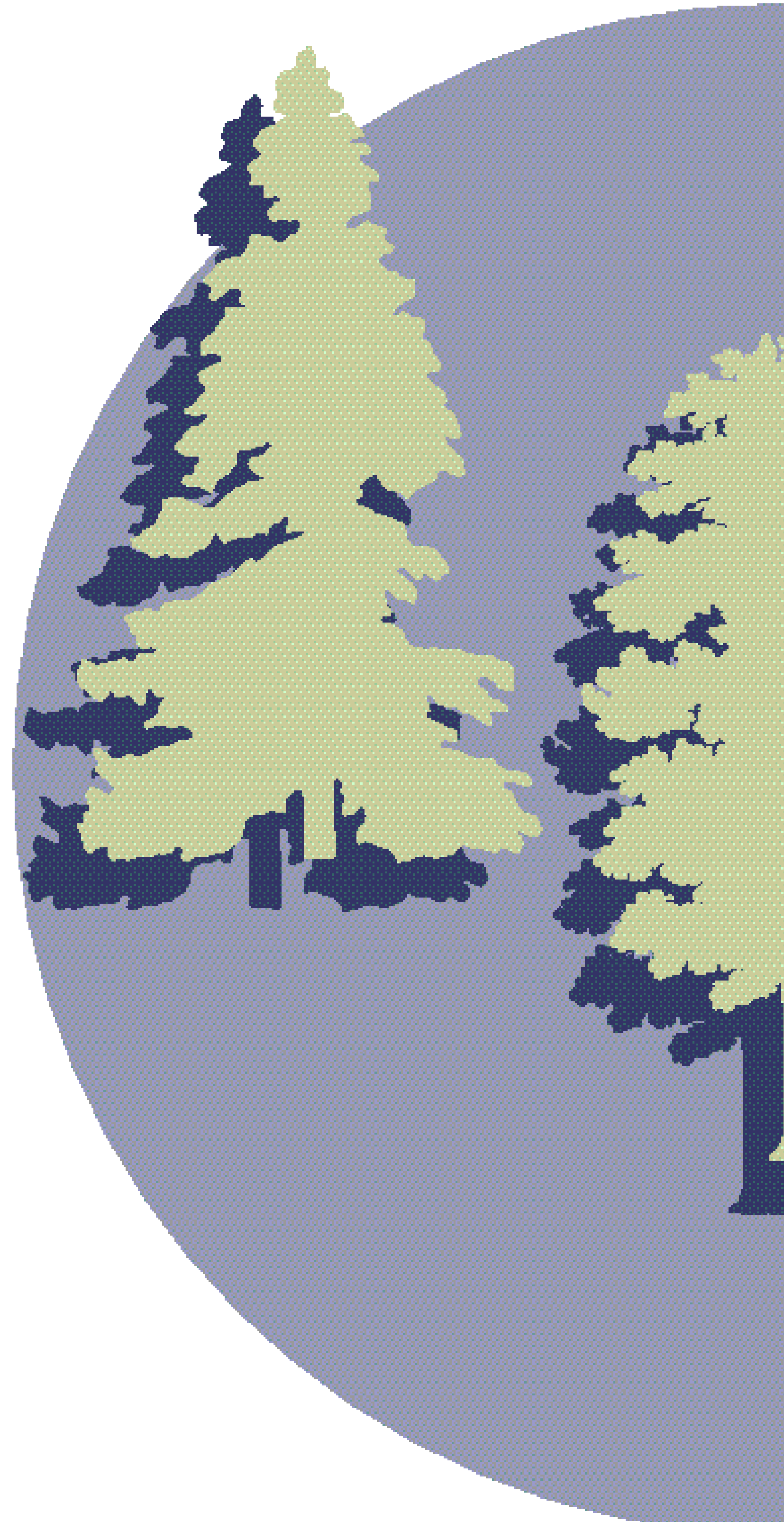

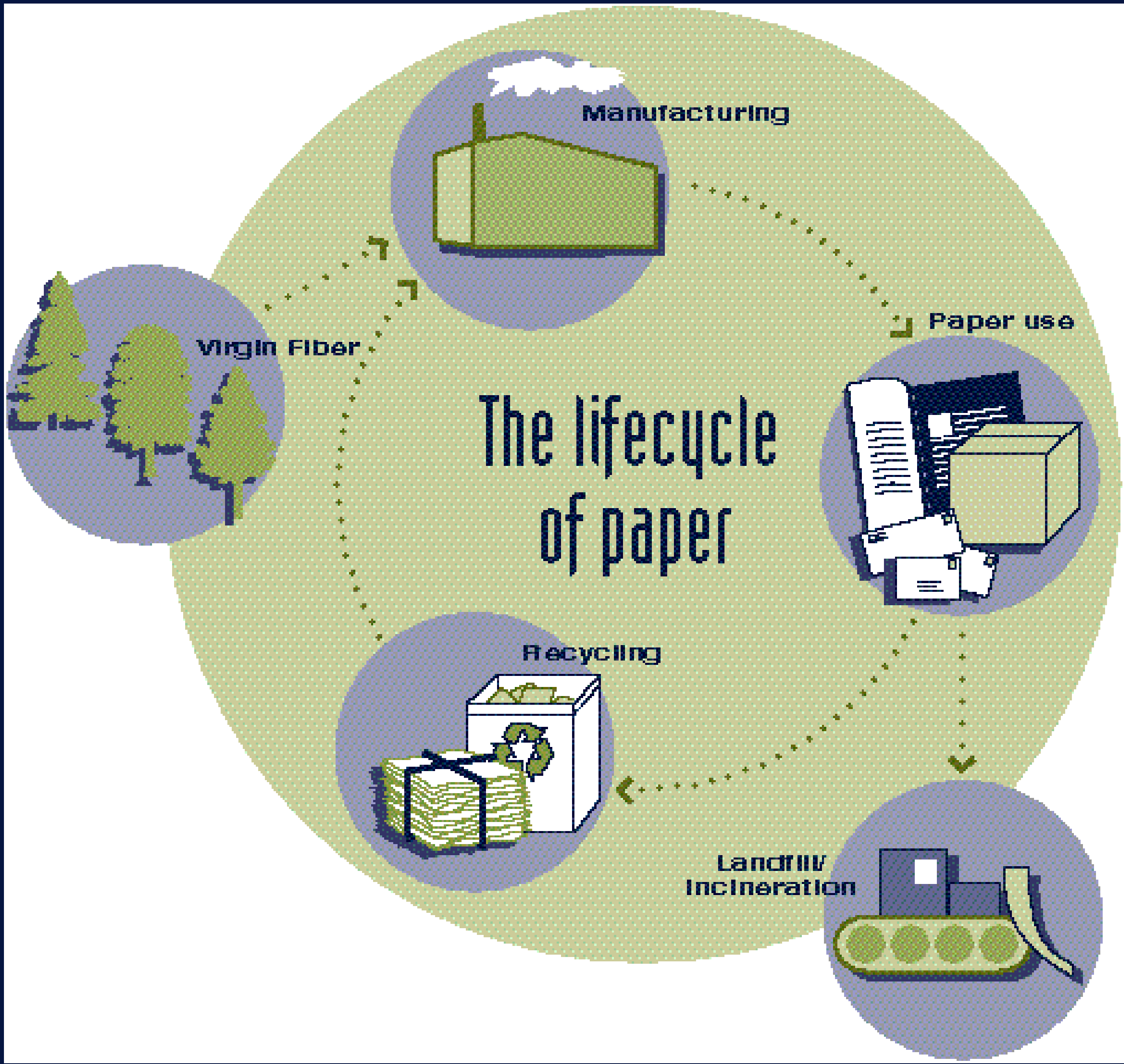
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Manufacturing
Paper use
Landfill/
Incineration
Recycling
Virgin Fiber

Introduction

1

Why paper? What's at stake?

What is the pulp and paper industry doing about all this?

The results

Types of paper examined

We all use paper — lots of it. The average American now uses nearly 700 pounds of paper each year — a doubling in per-capita consumption since 1960. And further growth in consumption is projected both in the United States and worldwide.

As with other materials, the use of all this paper carries with it a considerable impact on the environment. The members of the Paper Task Force came together to find ways to reduce these impacts. We comprise an unusual mix of partners: four of America's premier corporations from various sectors of the economy, a major university and a leading environmental advocacy organization. Each of our organizations purchases and uses large amounts of paper. We also share the common purpose of finding ways to increase the purchase and use of environmentally preferable paper. We've worked cooperatively to craft a voluntary, cost-effective initiative for environmental improvement.

By adopting a market-based approach grounded in the purchaser-supplier relationship, we seek to create demand for *environmentally preferable paper*, defined as *paper that reduces environmental impacts while meeting business needs*. This definition explicitly acknowledges that economic and performance considerations are central to purchasing decisions. It also defined the course of our more than two years of extensive research, during which we:

- developed a thorough understanding of *key performance characteristics* of various grades and uses of paper, and how such functional properties can be affected by changes in the fiber source or processes used to make the paper;
- reviewed available studies and developed our own analyses and models to elucidate the *economics* of paper production and use; and
- explored *environmental impacts* associated with the production and use of paper.

Through this approach, the Task Force met its goal: to identify ways to integrate environmental criteria into paper purchasing decisions on a par with traditional purchasing criteria, such as cost, availability and functionality. By so doing, we ensure that the right environmental choice also makes good business sense. Many of the Task Force's recommendations can cut costs and offer longer-term strategic advantages for purchasers, and, if adopted broadly, can positively reshape the overall economics of paper production and use. Our recommendations also can enhance emerging purchasing practices, such as strategic alliances, that are being adopted by successful business organizations.

Rather than considering only a single or a few attributes of paper — its recycled content, for example, or how it is bleached — the Task Force chose to examine the *entire lifecycle of paper*, literally from the forest to the landfill. We developed a basis for judging the available options that considers: how the fiber used in paper is *acquired*, whether from a forest or a recycling collection program; how that fiber is *manufactured* into a range of paper products; and how those products are *managed after use*, whether in landfills or incinerators or through collection for recycling.

We reviewed the published literature, analyzed data and had scores of internal meetings, but we also got away from the library, our offices and meeting rooms:

- We made more than 50 site visits to forests, pulp and paper mills, research facilities and recycling centers.
- We conducted more than 400 meetings and discussions with experts from the forest products industry, academia, environmental organizations, consulting firms and related businesses such as makers of office equipment.
- We subjected our research to extensive review by a range of experts.

Why Paper? What's at Stake?

Paper is an essential part of our lives and our work. At the same time, its use has major environmental and economic consequences.

Environmental impacts can arise across all stages of the lifecycle of paper:

Fiber Acquisition: Obtaining the fiber used to make paper products entails a range of environmental impacts. Collection and processing of recovered paper requires energy and can release pollutants to the environment, but these impacts need to be viewed from a larger perspective: by displacing some of the need for virgin fiber and extending the overall fiber supply, recycling can offset the environmental impacts of acquiring virgin fiber, making virgin paper and disposing of paper after use.

Acquiring virgin fiber from trees can significantly alter the ecological values or functions of forests. Because specific forest management activities, such as how trees are harvested or where roads are placed, can have immediate, localized effects on water quality, a number of steps, both regulatory and voluntary, have been taken to lessen their impact. However, the most significant impacts of forest management arise on a larger or longer scale, and these have been less effectively addressed by existing safeguards. These cumulative effects can include impairment of the integrity of natural ecosystems and the health and diversity of plant and animal species — and economic resources such as fisheries and recreation — dependent on them.

Pulp and Paper Manufacturing: Whether from recovered or virgin fiber, the process of making paper consumes large quantities of fresh water, chemicals and energy; pulp and paper is the fourth most energy-intensive manufacturing industry in the United States. Outputs from paper manufacturing processes include conventional and hazardous air and water pollutants released to the atmosphere and to bodies of water, as well as a variety of solid wastes.

The Task Force's research has shown that manufacturing processes based on recycled fiber, while still using resources and generating releases to the environment, generally require fewer inputs and generate fewer outputs than do virgin fiber manufacturing processes. We've also identified environmental preferences among the technologies and practices used to make virgin paper.

Used Paper Management: Managing used paper is also a source of environmental impacts. Waste collection, landfilling and incineration each generate releases of air and water pollutants (and, in the case of incineration, an ash residue that itself requires landfilling). Rapid increases in recycling have occurred over the last several years, yet paper still makes up one-third of all waste Americans send to landfills and incinerators. In fact, in 1994, approximately 20% of all paper produced *worldwide* was discarded in the United States. While not all such paper is capable of being recovered for recycling, an increase in the recovery rate from 40% (the 1994 level) to 50% would increase fiber supply worldwide by 3.3%.

The Cost of Paper to Business: Paper entails a considerable cost to businesses that use it in large volumes. The value of total shipments of paper from U.S. manufacturers in 1994 was $138 billion. This figure includes $55 billion for market pulp and paper in its basic form (large rolls) and $83 billion in value added from converting rolls of paper into products like corrugated boxes, paperboard cartons, envelopes, writing tablets, etc.[1] Paper is also a cost factor for — and the material that makes possible — entire business sectors such as publishing, catalog and direct mail retailing and commercial printing.

What is the Pulp and Paper Industry Doing about All This?

The environmental concerns described above are by no means new to the pulp and paper industry; indeed, many companies and the industry as a whole have been proactive in addressing them. Some examples are provided below.

Recycled Fiber Acquisition: The last decade has witnessed an unprecedented rise in the collection of used paper products for recycling, from about 27% in 1985 to just over 40% in 1994 (including both postconsumer finished paper products and preconsumer manufacturing scrap). Continued increases in the paper recovery rate are expected through the rest of the decade; the pulp and paper industry has set a goal of 50% recovery for the year 2000.[2] In the late 1980's paper manufacturers began installing significant additional deinking and recovered fiber processing capacity, projected to amount to an investment of more than $10 billion over a decade.

The Task Force's recommendations directly bolster this investment in recycling by calling for action by organizations that purchase and use paper on both the supply and demand sides of the recycling equation.

Virgin Fiber Acquisition Through Forest Management: The American Forest & Paper Association (AF&PA) recently issued a Sustainable Forestry Initiative (SFI) that sets out guiding principles for changing how forests are managed so as to sustain, not only the output of forest products, but also non-timber values provided by forests, such as soil, air and water quality, wildlife and fish habitat, and aesthetics. The initiative is the most comprehensive expression of the industry's collective effort to improve forest management on its lands. It also commits AF&PA member companies to encourage similarly sustainable practices on the part of others, such as loggers and other landowners from whom they purchase wood. As expected for an initiative developed by the industry's trade association, the guidelines do not contain specific performance standards in most areas, leaving the administration and execution of the stated objectives up to individual companies.

The SFI provides a useful point of reference for the recommendations of the Paper Task Force, many of which reinforce the principles articulated in the industry's guidelines. Because our recommendations are intended to be implemented by purchasers working with individual forest products companies, they set out more specific performance measures that purchasers can use to assess or compare individual suppliers' practices and other activities.

Other private-sector initiatives toward sustainable forestry that involve or potentially affect the pulp and paper industry have been developed recently. A 1993 report entitled "Sustaining Long-term Forest Health and Productivity," was issued by the Society of American Foresters (SAF), the professional organization representing the forestry profession as a whole; it represents a recognition by much of the profession of the need for new approaches to forest management. In 1994, the Forest Stewardship Council (FSC), an independent, international body being set up to accredit organizations to certify forest management practices, issued its "Principles and Criteria for Natural Forest Management," which embody a set of environmental objectives remarkably similar to those articulated in the AF&PA and SAF initiatives just described: conservation of "biological diversity and its associated values, water resources, soils and unique and fragile ecosystems and landscapes." The SFI, SAF and FSC initiatives are all discussed in Chapter 4 of the Task Force's main report.

Our recommendations bolster investments in recycled paper manufacturing by calling for action by organizations that purchase and use paper on both the supply and demand sides of the recycling equation.

Pulp and Paper Manufacturing: Over the last several decades, the nation's environmental laws and industry efforts have produced substantial reductions in pollution from pulp and paper manufacturing. Since 1970, the industry has invested over $10 billion to install *pollution-control* systems and practices at pulp and paper mills to reduce releases of pollutants to the environment. As a result, releases of conventional air and water pollutants have declined by 80-90% over the last 25 years. More recently, the industry has spent additional capital to install *pollution-prevention* technologies. For example, by reducing their use of elemental chlorine, bleached kraft pulp mills have reduced releases of dioxin by over 90% since 1988, and further substantial reductions in chlorine use are underway. In addition, several paper companies have installed or made commitments to install more advanced technologies at bleached kraft pulp mills that can significantly reduce the quantity as well as improve the quality of their discharges to air and water. Finally, the American Forest & Paper Association has identified additional research directions for new pulping, bleaching and recovery systems as part of its *Agenda 2020*.

The Task Force recommendations build on these industry initiatives, by informing purchasers of these technological advances. This will allow purchasers to buy paper made with environmentally preferable systems and processes that further reduce natural resource consumption and releases to the environment.

The Task Force believes that organizations that purchase and use paper have a vital role to play in realizing further environmental improvements in each of the areas we have studied. The purchaser-supplier relationship is an appropriate and powerful vehicle for developing and implementing cost-effective, market-based solutions to the environmental challenges in these areas. Our recommendations are intended to facilitate this process.

The Results

The Task Force has produced a variety of tools for organizations that use paper:

- A set of actionable *recommendations* (a summary of which is provided in the Appendix), each accompanied by a menu of *implementation options*, with which paper purchasers and users can systematically integrate environmental considerations into their operating procedures and purchasing decisions, alongside cost, performance, service and other traditional purchasing criteria.[3]
- Environmental, economic, and product performance *rationale* for the recommendations, as well as *answers to key questions* likely to arise in the course of their implementation.
- A decision framework with specific *action steps* (see below) that organizations that purchase and use paper can employ in examining their overall paper use and in applying the Task Force's recommendations to identify opportunities to effect positive environmental change.
- A set of detailed, fully documented *White Papers* that present all of the Task Force's technical research.

Together, these Task Force products comprise a *purchasing model* for organizations that buy and use paper and that seek to lessen the environmental impact of their paper use.

Types of Paper Examined

The recommendations of the Paper Task Force focus on three major categories of paper products:

- printing and writing papers, including those used in publications as well as in business and office applications
- corrugated shipping containers
- folding cartons used to package consumer goods for retail sale

These categories together represent approximately 70% of all paper used in the United States.

What Can a Purchaser Do?

2

Approaches to implementing the recommendations

Five steps for direct action

Approaches to Implementing the Recommendations

The Task Force's recommendations provide actionable steps that organizations that purchase and use paper can take to reduce paper use and address forest management, manufacturing and recycling.

Purchasers buy paper through a variety of entities. Those who buy directly from specific mills or paper companies can implement the Task Force's recommendations using these established relationships. Environmental factors can be introduced as purchasing considerations in the same manner as product quality, price, availability and service.

Other purchasers buy from office supply stores, printers, packaging converters, or paper brokers who in turn buy from manufacturers or other intermediaries. These purchasers can directly request of their vendors paper products with certain environmental attributes, such as recycled content. More generally, they can express their preferences to these vendors, and request that they pass such information back up *their* supply chain. Intermediary suppliers can be encouraged or requested to adopt these recommendations in their capacity as paper purchasers. Proactive purchasers may wish to link their volume of business with such vendors to the extent to which they offer papers made using fiber produced in accordance with these recommendations.

Depending on the specific nature of the purchasing relationship, purchasers can take several basic approaches to apply the recommendations:

- *Work with existing suppliers.* Paper purchasers can use the recommendations to communicate their preferences to existing suppliers or vendors, and work with them to modify existing products, practices or technologies or introduce new ones.
- *Comparison shop.* Paper purchasers can evaluate and preferentially buy from existing and prospective suppliers based on the degree to which suppliers offer products or employ practices that are consistent with the recommendations (and the purchasers' economic and paper performance needs).
- *Measure progress.* Purchasers can use the recommendations to establish criteria by which they will evaluate a current supplier's progress and continuous improvement over time. Estab-

ng milestones and reporting mechanisms for tracking ogress can be used to ensure accountability and results.

- *Send a signal.* Purchasers can use the recommendations to send signals to existing and prospective suppliers that, functional and economic needs being met, they ''' shift their paper purchases over time to suppli- who adopt preferred practices and develop pre- rred products.

As these approaches to the Task Force recommendations are put to use at each step of the decision framework described below, environmental priorities and functional and economic needs specific to a given organization will need to be considered in deciding the extent to which that step can be applied to the organization's paper use.

Direct Action

Five steps for direct action

- Step 1: Understand your paper use.
- Step 2: Look for opportunities to reduce paper use.
- Step 3: Look for opportunities to recycle your paper and work with others to do the same, and to buy paper with postconsumer recycled content.
- Step 4: Look for opportunities to buy paper made by suppliers that employ environmentally preferable forest management practices to produce virgin fiber.
- Step 5: Look for opportunities to buy paper made by suppliers that employ environmentally preferable pulp and paper manufacturing technologies and practices.

Five Steps for Direct Action

The following decision framework can aid a purchaser in evaluating his or her organization's overall paper use and in identifying opportunities to apply environmental preferences. The steps laid out below lead the purchaser through a logical progression of decision points to apply to an organization's paper use. They provide a systematic way to apply the various sets of Task Force recommendations, in order to conduct a full assessment of improvement opportunities.

Only the basic steps of the decision framework and a brief rationale are provided below, as an overview. When using the framework, purchasers should refer to the recommendations contained in the Task Force's main report.

Step 1. Understand your paper use.

ıe logical starting point is to develop a baseline "inven- " of your paper use. Identify the major uses, approximate ties used, mode of purchase and amounts distributed h business activities, disposed of and recycled.

Step 2. Look for opportunities to reduce paper use.

Reducing paper use (a form of *source reduction*) can take the form of eliminating a given use of paper altogether. For example, business forms can be consolidated or a layer of packaging can be eliminated. Or less paper can be used in a given application. For example, printing and copying can be done on both sides of a page or the basis weight of paper used in a publication can be reduced. When carried out in a manner consistent with functional and other constraints, source reduction offers major environmental and economic benefits. By reducing the amount of paper that is used in the first place, environmental impacts resulting from all stages of the lifecycle of paper are entirely avoided. Using less paper can also save money — less paper to purchase, less storage or filing space needed, and less used paper to manage. While cost savings may seem to provide ample incentive to reduce paper use, many studies have identified significant opportunities for further reductions in even the most efficient business operations.

In Chapter 2 of the Task Force's main report, we offer recommendations and implementation options for reducing the use of paper in different settings, as well as references to other resources available to the purchaser.

Of course, no matter how much source reduction you achieve, most businesses will still purchase and use plenty of paper. For the paper you do use, along with considering availability, functional performance and price:

Step 3: Look for opportunities to recycle your paper and work with others to do the same, and to buy paper with postconsumer recycled content.

Paper recycling is good for the environment. The Task Force's extensive research shows that, compared to virgin paper production and disposal, recycled paper production and recovery generally result in significantly lower environmental releases of numerous air and water pollutants, less solid waste and lower consumption of energy and forest resources.

For paper users acting in the aggregate, increasing the collection of paper for recycling while expressing a preference for paper with recycled content is a *strategic approach to containing prices* for new paper products. Increased collection of paper for recycling makes more raw materials available for paper manufacturers and can also reduce solid waste disposal costs and earn paper users revenues from selling the recovered paper. Maximizing the purchase of recycled paper consistent with economic and functional requirements encourages manufacturers to invest further in recycling-based manufacturing capacity and research and development. Within this context, it should be noted that the comparative cost of manufacturing virgin and recycled paper varies among different grades and among mills.

Recycling ultimately provides paper manufacturers with an important means of adding productive capacity, and provides purchasers with greater choices among paper products. Growth in recycling-based paper manufacturing capacity is now outpacing growth in virgin paper production capacity. Between 1984 and 1994, total production of pulp from wood grew by 10.2 million tons, while total consumption of recovered paper by U.S. manufacturers grew by 13.3 million tons.[4] At least in some pulp and paper grades, the advent of this recycling capacity is already creating lower prices for paper purchasers.[5]

Purchasers should also identify steps that will enhance the ability to collect paper within their business operations, whether in-house or in the products they distribute. Options to consider include:

- Developing in-house recycling collection programs, and expanding such programs to include used paper generated in employees' homes.
- Initiating or participating in efforts to spur greater paper recovery in the communities in which the purchaser's business operates, by working with other companies that generate used paper, business organizations, local government and recycling and waste management companies.
- Identifying items that can be redesigned to increase the ease with which they can be recycled (for example, by eliminating coatings on boxes, eliminating or switching adhesives on labels or bindings, or eliminating windows in envelopes).

Step 4. Look for opportunities to buy paper made by suppliers that employ environmentally preferable forest management practices to produce virgin fiber.

No matter how successful you are at recycling and buying recycled paper, a large part of the paper you purchase will likely still contain virgin fiber. An input of virgin fiber is necessary to sustain a balance with used paper that is recycled, and to maintain the physical properties of paper products. When buying paper containing virgin fiber, consider how impacts arising from acquiring it can be reduced.

The Task Force has identified a number of recommendations to address the major environmental impacts of forest management practices used for fiber production. The recommendations serve three key objectives:

- Lands owned by forest products companies should be managed in a manner that preserves and enhances the full range of environmental values forestlands provide.
- Sound environmental management practices should be extended to non-industry lands from which forest products companies buy wood.
- Sound forest management should be promoted at a landscape level and across ownership boundaries, including increased support for natural and less intensive forms of management on public and non-industry private lands.

> No matter how successful you are at buying recycled paper, you will likely purchase a lot of paper containing virgin fiber. When buying such paper, consider how impacts arising from fiber acquisition and manufacturing can be reduced.

Because forest products companies have direct control over practices used on their own lands, purchasers can work with their existing suppliers to implement preferred practices or identify new suppliers that use such practices on their own lands already. However, the majority of pulpwood is harvested from lands not owned by forest products companies. Here the purchaser's role is to encourage his or her suppliers to exert influence over their wood suppliers, through their own purchasing relationships as well as other available means.

Finally, to address the most serious and large-scale impacts of forest management on entire ecosystems and plant and animal diversity, it is essential that forest management planning cross ownership boundaries to ensure the integrity and functioning of these communities and ecosystems. Purchasers can make clear their intention to evaluate and compare their suppliers based on the leadership, commitment and cooperation they display in the areas in which they operate.

As a starting point, purchasers may wish to survey their suppliers' practices relating to one or more of the Task Force's recommendations, and to set minimum requirements for all their suppliers, including, for example, full compliance with Best Management Practices. Purchasers can then identify specific Task Force forestry recommendations that they will introduce in their discussions with existing and prospective suppliers.

Step 5. Look for opportunities to buy paper made by suppliers that employ environmentally preferable pulp and paper manufacturing technologies and practices.

Within the manufacturing area, each of the following evaluative steps can be followed:

- *Consider the manufacturing processes used at the mills owned by your suppliers. For example, give preference to paper made by suppliers who*:
  - articulate a vision of a *minimum-impact* mill.[6] Suppliers should be able to provide a definition of the minimum - impact mill that includes their long-term goals for environmental performance.
  - implement sound environmental management approaches in the daily operations of their mills and comply with environmental regulations.
  - demonstrate continuous environmental improvement by installing pollution-prevention technologies at their mills. For bleached kraft pulp mills, purchasers should consider assessing and comparing pulping and bleaching technologies, including the following:

  (a) The replacement of elemental chlorine with chlorine dioxide in the bleaching process reduces the discharge of chlorinated organic compounds, including dioxins.

  (b) Oxygen delignification and extended delignification are two available, proven and cost-effective manufacturing technologies that form a foundation for progress towards the minimum-impact mill. These technologies allow mills to increase their recovery of organic waste and reduce chemical consumption in the bleach plant.

  (c) Technologies that allow for the reduction or elimination of process water discharge from the bleach plant represent additional progress towards the goal of the minimum - impact mill and are the most advanced processes currently available. These technologies, which include ozone-based elemental chlorine-free and totally chlorine-free bleaching systems, recirculate most of the process water within the mill instead of treating and discharging it to the environment. In the process, such mills burn more organic wastes to produce energy and recover more chemicals for reuse.

  (d) New technologies may emerge that offer other ways to achieve the goal of the minimum-impact mill. For example, a mill-scale demonstration has begun for a process that removes chlorides from mill process water to facilitate the recirculation of bleach plant filtrates.

- *Consider the types of pulps used to make the products you purchase. For example*:
  - Identify opportunities to incorporate alternatives to bleached pulps, including high-yield pulps (which make the most efficient use of wood, chemicals and water) and unbleached pulps (which reduce chemical use in the manufacturing process).

It is in purchasers' economic interest to send a long-term signal of support for pollution prevention in pulp and paper manufacturing. By using pollution-prevention approaches, suppliers can design environmental improvement into manufacturing processes. Michael Porter, an expert on competitive strategy at the Harvard Business School, observes that "[l]ike defects, pollution often reveals flaws in the product design or production process. Efforts to eliminate pollution can therefore follow the same basic principles widely used in quality programs: Use inputs more efficiently, eliminate the need for hazardous, hard-to-handle materials and eliminate unneeded activities."[7]

A study of 50 manufacturers of white pulp and paper in six countries found that the longer a firm had invested in pollution-prevention technologies in its bleaching process, the better its economic performance.[8] Over the long term, paper users are better served by suppliers that use practices or technologies that lessen the likelihood of unwanted environmental surprises. Suppliers with lower manufacturing costs will gain a competitive edge in the global paper market and will be best prepared to meet the needs of paper purchasers and users.

A Preview of the Task Force's Report

3

The full report of the Paper Task Force comprises two volumes.

Volume I, the main report, consists of five chapters. Chapter 1, "Setting the Stage for Buying Environmentally Preferable Paper," presents the context for understanding and acting on the Task Force's recommendations. It describes:

- The origin, scope and process of the Task Force project
- The Task Force's research process and our approach to assessing paper performance, economics and environmental impacts
- The key functional requirements for the grades of paper we examined
- The basic activities involved in forest management, pulp and paper manufacturing, paper recycling and waste disposal, and their environmental impacts
- The basic economics of paper production and purchasing

Chapters 2-5 set out the Task Force's recommendations, a summary of the supporting rationales, and implementation options for purchasers, in each of four areas:

- Source reduction
- Paper recycling and buying recycled paper
- Forest management
- Pulp and paper manufacturing

Volume II, the technical supplement, provides the underlying technical research supporting the Task Force's recommendations, in the form of 16 fully documented and externally reviewed White Papers that cover functional, economic and environmental aspects of each major issue examined by the Task Force.

Copies of the Task Force's report can be ordered using the form at the back of this synopsis. Or contact: Public Information, Environmental Defense Fund, 257 Park Avenue South, New York, NY 10010; (212) 505-2100; or use EDF's home page on the World Wide Web: www.edf.org

APPENDIX

Paper Task Force Recommendations

The Task Force has developed recommendations in each of four areas:

- Source Reduction
- Recycling and Buying Recycled Paper
- Forest Management
- Pulp and Paper Manufacturing

These recommendations are summarized below. The Task Force's main report contains the full version of these recommendations, including important contextual information, the economic, performance and environmental rationale for the recommendations and implementation options for purchasers. The full versions should be reviewed as a basis for acting on the recommendations.

These recommendations were developed and intended for implementation primarily in the context of pulp and paper production and purchasing within North America, with a particular focus on the United States. While we examined technologies and practices used to produce pulp and paper in other areas of the world, our recommendations are directed toward purchasers of paper produced in the United States.

Source Reduction

Recommendation. Systematically identify opportunities and take action to reduce the use of paper, and the amount of fiber used in specific paper products, both within your organization and in paper products related to your business, where consistent with functional considerations.

Recycling and Buying Recycled Paper

Recommendation 1. Paper users should actively expand and optimize paper recycling collection programs. Paper users also should promote recycling activities and assist efforts to develop the paper recycling infrastructure in the following areas, as appropriate to the capabilities of your organization:

- within the premises of your business
- for the products distributed by your company or your industry
- in the communities in which your business operates
- among the broader business community and general public

Recommendation 2. Paper purchasers should maximize their overall use of paper with postconsumer recycled content, consistent with functional and economic considerations.

Recommendation 3. Paper users and purchasers should design or purchase paper products that can be recycled readily after their use.

Forest Management

Recommendations to advance management of lands owned by forest products companies in a manner that preserves and enhances the full range of environmental values forestlands provide.

Recommendation 1. Purchasers should demonstrate a preference for paper made by suppliers who — at a minimum — operate in compliance with the principles and implementation guidelines for sustainable forestry as published by the American Forest & Paper Association (AF&PA), collectively known as the Sustainable Forestry Initiative (SFI), and should buy only from suppliers in compliance with all applicable environmental laws and regulations.

Recommendation 2. Purchasers should demonstrate a preference for paper made by suppliers that manage their lands in a manner that protects on- and off-site water quality and conserves soil productivity. Such management includes operating in full compliance with all applicable mandatory or voluntary Best Management Practices (BMPs) and other applicable laws and regulations related to water quality, as well as any additional steps needed to meet the objective.

Recommendation 3. Purchasers should demonstrate a preference for paper made by suppliers who develop and implement an adaptive management approach, through actively engaging in and keeping abreast of research on the environmental impacts of forest management practices, coupled with a commitment to modify their practices as needed in response to research results.

Recommendation 4. Purchasers should demonstrate a preference for paper made by suppliers who actively seek outside assistance, advice and perspective from the full range of other stakeholders and interested parties in issues surrounding forest management.

Recommendation 5. Purchasers should demonstrate a preference for paper made by suppliers who manage their lands in a manner that contributes to the conservation of biodiversity by maintaining or enhancing habitat for a broad array of plants and animals, with an emphasis on rare and endangered species.

Recommendation 6. Purchasers should demonstrate a preference for paper made by suppliers who manage their lands in a manner that preserves ecologically important, rare or declining natural communities. Intensive management on lands representing such community types should be avoided; where necessary for preservation, management for wood production should not take place. Intensive management should be concentrated on lands of lower ecological value.

Recommendation 7. Purchasers should demonstrate a preference for paper made by suppliers who employ harvesting methods that minimize the ecological impacts of harvesting, both at the level of individual stands of trees and across the landscape.

Recommendation to extend environmentally sound management practices to non-industry lands from which forest products companies buy wood for their products.

Recommendation 8. Purchasers should demonstrate a preference for paper made by suppliers who use available means to ensure that environmentally sound practices are applied to the management of all lands from which the supplier buys wood. These requirements should extend to wood bought on the open market, commonly known as "gatewood."

Recommendations to promote environmentally sound forest management at a landscape level and across ownership boundaries, including increased support for natural and less intensive management on public and non-industry private lands.

Recommendation 9. Purchasers should demonstrate a preference for paper made by suppliers who encourage and participate in the development of environmentally responsible management on a landscape level, including the implementation of management approaches that are applied across ownership boundaries.

Recommendation 10. Purchasers should demonstrate a preference for paper made by suppliers who show environmental leadership by actively promoting efforts to manage non-industry lands (both public and private) so as to maintain and enhance the extent and environmental value of the nation's forestlands. Suppliers should actively support and encourage management of such lands using non-intensive approaches so as to provide and preserve ecological values that are more limited or difficult to provide on more intensively managed industry lands.

Pulp and Paper Manufacturing

Minimum-impact Mills.

Recommendation 1. Purchasers should give preference to paper manufactured by suppliers who have a vision of and a commitment to minimum-impact mills – the goal of which is to minimize natural resource consumption (wood, water, energy) and minimize the quantity and maximize the quality of releases to air, water and land. The minimum-impact mill is a holistic manufacturing concept that encompasses environmental management systems, compliance with environmental laws and regulations and process technologies.

Recommendation 2. Purchasers should give preference to paper products manufactured by suppliers who demonstrate a commitment to implementing sound environmental management of their mills. Suppliers should demonstrate progress in the following areas:

- improved spill-prevention and control systems based on the installation of available technologies;
- preventive maintenance programs;
- emergency preparedness and response programs;
- improving the energy efficiency of mill operations through the installation of energy-conservation technologies;
- on-going training for mill staff in process control and their role in improving environmental performance; and
- internal auditing procedures that include qualitative and quantitative measures of performance.

Purchasers should consider their suppliers' compliance records as one indicator of an effective environmental management system.

Recommendation 3. Purchasers should give preference to paper manufactured by suppliers who demonstrate continuous environmental improvement toward minimum-impact mills by installing pollution-prevention technologies.

- The substitution of chlorine dioxide for elemental chlorine in the first stage of the bleaching process reduces the discharge of chlorinated organic compounds.
- The installation of oxygen delignification and extended cooking, two available and proven cost-effective manufacturing technologies that maximize lignin removal in the pulping process, forms a foundation for further progress toward the minimum-impact mill.
- Mills that recirculate the filtrates from the first bleaching and extraction stages of the bleach plant make additional progress toward the minimum-impact mill. These low-effluent processes represent the most advanced current technologies.
- Future technologies may emerge that make additional progress toward the minimum-impact mill.

Product reformulation by changing the types of pulps used in paper products.

Recommendation 4. Purchasers of paper packaging, such as corrugated boxes and folding cartons, should seek to purchase paper products made of unbleached kraft paperboard rather than bleached kraft paperboard in cases where the packaging meets functional and economic requirements.

Recommendation 5. Purchasers of coated printing and writing papers should express their preference for paper that increases the substitution of mechanical pulp for bleached kraft pulp in cases where the paper meets functional and economic requirements.

Recommendation 6. Purchasers of printing and writing papers should express their preference for paper that substitutes bleached kraft for bleached sulfite pulps in cases where the paper meets functional and economic requirements.

Recommendation 7. Purchasers of coated and uncoated freesheet paper should consider paper products that contain bleached chemithermomechanical pulp (BCTMP) as a partial substitute for hardwood kraft pulp in cases where the paper is available and meets functional and economic requirements.

Recommendation 8. Purchasers should be open to considering paper products that contain non-wood agricultural residue fiber in cases where the products are available and meet functional and economic requirements.

ENDNOTES

[1] American Forest & Paper Association, *Paper, Paperboard & Wood Pulp, 1995 Statistics*, Washington, DC: AF&PA, September, 1995, p. 76. Based on data from the U.S. Department of Commerce, Bureau of the Census.

[2] The 1994 recovery rate of 40% and the industry's 50% goal (announced in 1994 by the American Forest & Paper Association), in addition to including preconsumer paper, are calculated in a manner that: (1) excludes paper imported into the U.S. as packaging (e.g., corrugated boxes and cartons for Canadian products); and (2) includes the weight of moisture and contaminants present in collected used paper. These factors tend to inflate the apparent "recovery rate."

[3] A summary version of the Task Force's recommendations is attached in the Appendix. The full versions of the recommendations and implementation options appear in Chapters 2-5 of the main report.

[4] American Forest & Paper Association, *Paper, Paperboard & Wood Pulp, 1995 Statistics*, Washington, DC: AF&PA, September, 1995, p. 56.

[5] The case where this is most evident is linerboard and corrugating medium used to make corrugated boxes. Between 1990 and 1995, total U.S. paper and paperboard production capacity is projected to grow from 84.4 to 94.9 million tons per year (12.4%). Total containerboard capacity is projected to grow from 28.4 to 33.0 million tons per year over the same period (16%). Of the 4.6 million tons of containerboard capacity growth, 3.0 million tons will be 100% recycled containerboard and an additional increment will be a recycled/virgin mix. American Forest & Paper Association, *Paper, Paperboard & Wood Pulp, 1995 Statistics*, Washington, DC: AF&PA, September, 1995, p. 33. When prices for old corrugated containers and mixed paper are within their historical range, capital and operating costs are generally lower for recycling-based expansions compared to new virgin containerboard capacity. Paper Task Force, White Paper No. 9. The new containerboard capacity is moderating potential price increases. "Containerboard market awash in production as new capacity ramps up better than expected," *Pulp & Paper Week*, October 9, 1995, pp. 1-3. A similar case could be made that deinked market pulp is affecting prices for its functional competition, virgin hardwood market pulp, in comparison to virgin softwood market pulp. Deinked market pulp now makes up roughly 10% of U.S. market pulp production. Increased BCTMP pulp and Indonesian hardwood market pulp also affect the global hardwood pulp pricing equation, however.

[6] The goal of a minimum-impact mill, as defined by the Task Force, is to minimize natural resource consumption (wood, water, energy) and minimize the quantity and maximize the quality of releases to air, water and land.

[7] Michael Porter and Claas van der Linde, "Green and Competitive: Ending the Stalemate," *Harvard Business Review*, September-October 1995, pp.120-34.

[8] Chad Nerht, "Spend more to show rivals a clean pair of heels," *Pulp & Paper International*, 37(6): 81-82 (1995).

AUTHORS

Duke University

Paul Brummett
Evelyn Hicks

Environmental Defense Fund

Lauren Blum
Robert Bonnie
Richard A. Denison
Nat Keohane
Annette Mayer-Ilmanen
Jane B. Preyer
John F. Ruston
Melinda Taylor

Johnson & Johnson

Harold J. Capell
Brenda S. Davis
Barbara M. Greer
Anthony A. Herrmann
Peter Turso

McDonald's Corporation

Linda Croft
Bob Langert

The Prudential Insurance Company of America

Joe DeNicola
Steve Ritter

Time Inc.

David J. Refkin
David Rivchin

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Duke University

Dr. Stephen Boyce
Dr. Norman Christensen
Dr. Richard DiGiulio
Stephanie Finn
Dr. Douglas Lober
Dr. Daniel Richter
David Roberson
Dr. Aarne Vesilind
Duke University School of the Environment graduate students:
- Teos Abadia
- Chris Benjamin
- David Cohen
- Jonathan Cosco
- Jason Karas
- Elizabeth McLanahan
- Kerry Mularczyk
- Pamela Niddrie
- Mark Rampolla
- Paul Schinke
- Stewart Tate

Environmental Defense Fund

Maxine Adams
Bob Braverman
Mechelle Evans
Alexandra Haner
Suzanne Hamid
Steven Levitas
Allan Margolin
Diane Minor
Ciara O'Connell
Diane Pataki
Jackie Prince Roberts
Eliza Reed
Karen Roach
Melody Scott
Sandin Wang

Johnson & Johnson

Suzanne Goggin
Bill Hoppes
Jeff Leebaw
Elizabeth Richmond
Karl Schmidt

McDonald's Corporation

Iris Kast
Dave Kouchoukos
Tauquincy Miller
Walt Riker

NationsBank Corporation

Bruce Lawrence
Saundra Neusum

The Prudential Insurance Company of America

Mary Donelik
Rachel Ingber
Paul Lambdin
Marijane Lundt
Bob Zanisnik

Time Inc.

Elaine Alestra
Peter Costiglio
Barry Meinerth
Deane Raley, Jr.

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1

SETTING THE STAGE FOR PURCHASING ENVIRONMENTALLY PREFERABLE PAPER

I

Introduction

II

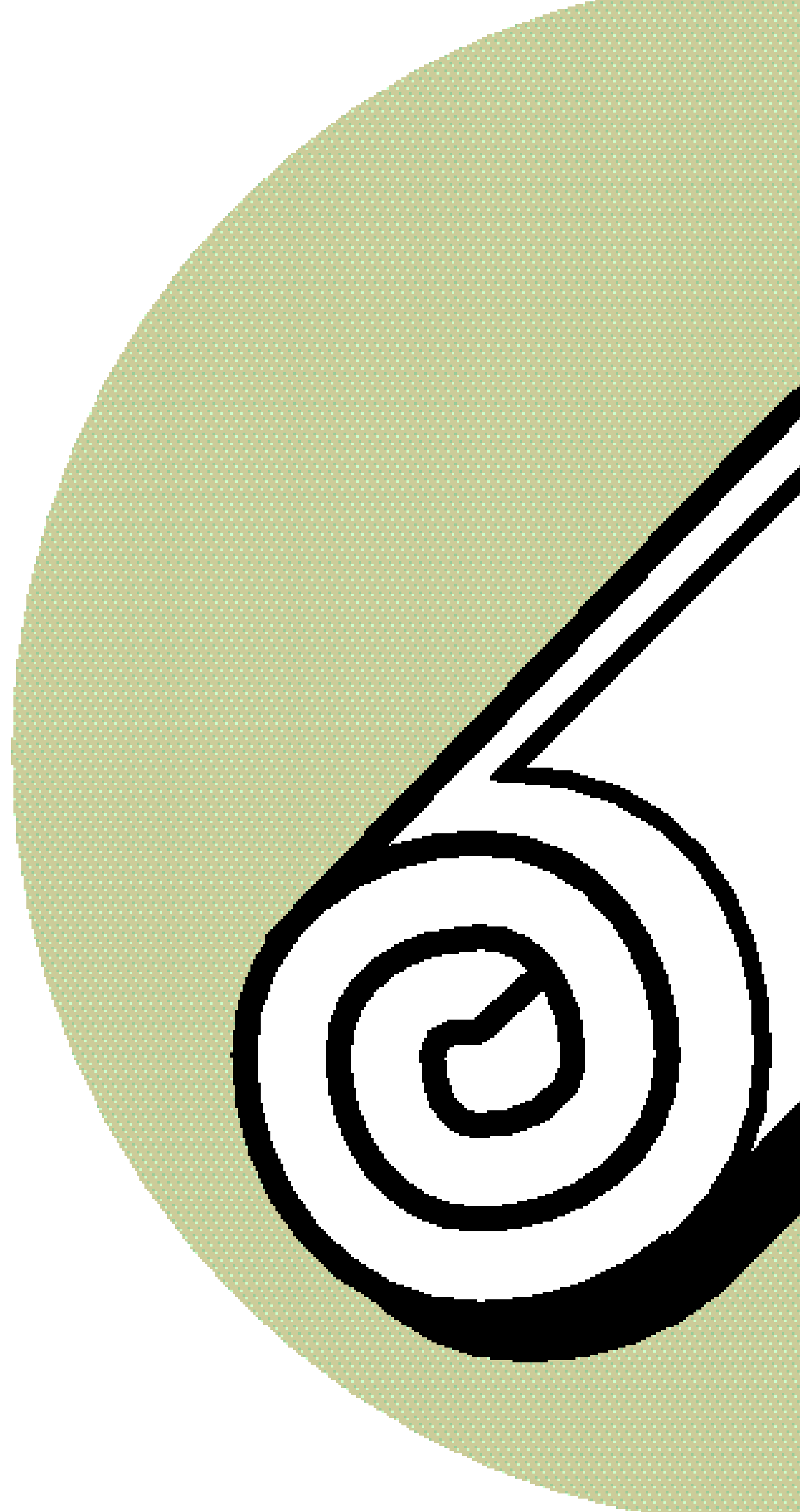
Scope and process of the Paper Task Force

III

Key findings on functional requirements for various grades of paper

IV

The economic structure of the pulp and paper industry and its relation to paper purchasing



SETTING THE STAGE FOR PURCHASING ENVIRONMENTALLY PREFERABLE PAPER

To set the stage, this chapter describes:

- The origins of the project and its purpose.
- The types of paper examined (and not examined) by the Task Force.
- The scope of our research and the thoroughness of our research process.
- The methodologies we employed in assessing paper performance, environmental issues and economic considerations.
- The nature of activities involved at each stage in the lifecycle of paper.
- Key findings concerning functional requirements for the various grades of paper examined by the Task Force.
- An overview of the structure of the pulp and paper industry.

I. INTRODUCTION

The goal of the Paper Task Force's recommendations is to integrate environmental criteria into paper purchasing decisions on par with traditional purchasing criteria, such as cost, availability and functionality. The Task Force's recommendations offer organizations that purchase and use paper the means to work within purchaser-supplier relationships to enhance environmental quality in ways that are also cost-effective and make good business sense. By demonstrating demand for paper products that are produced using environmentally preferable methods, paper purchasers can also directly reinforce and accelerate the positive changes in practices and technological investments that are already underway in the pulp and paper industry.

This chapter provides the context and introductory information needed to understand and act on the Task Force's recommendations. To set the stage, the chapter describes:

- the origins of the project and its purpose
- the types of paper examined (and not examined) by the Task Force
- the scope of our research and the thoroughness of our research process
- the methodologies we employed in assessing paper performance, environmental issues and economic considerations
- the nature of activities involved at each stage in the lifecycle of paper
- key findings concerning functional requirements for the various grades of paper examined by the Task Force
- an overview of the structure of the pulp and paper industry

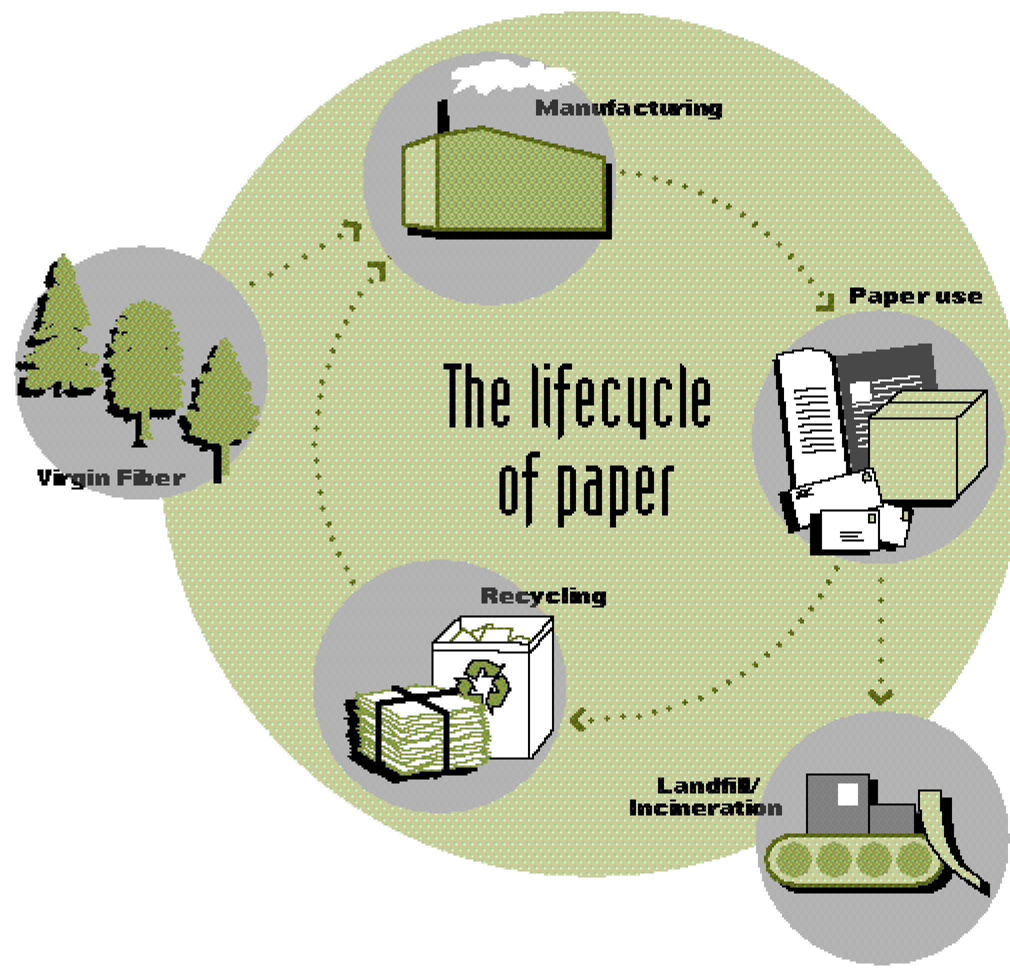
Beginning in late 1992, the Environmental Defense Fund (EDF) began contacting private-sector organizations that purchase and use paper to gauge their interest in participating in a voluntary, private-sector initiative for the purpose of identifying ways to reduce the environmental impact of paper use. The project sought to assemble organizations that represented leaders in a diversity of paper-intensive business sectors, and that purchased significant amounts of paper in a sufficient variety of grades to encompass most types of paper used in the United States. The project offered an opportunity for Task Force members, working in partnership with other leading organizations, to respond proactively to environmental concerns related to their own and others' use of paper.

At the outset, the Task Force developed a workplan that ensured a thorough process with ample opportunity for input from other stakeholders. As described in more detail in the next section, the Task Force's research was conducted in the context of a full and open dialogue with experts from the pulp and paper industry and affiliated businesses, and from the environmental, academic and financial communities. Task Force members worked closely with their paper suppliers throughout the process.

The Paper Task Force was specifically designed as a voluntary, private-sector initiative; our aim was to develop a body of information and a model that organizations that buy and use paper could employ to identify opportunities for environmental improvement. For this reason, the Task Force intentionally did not take positions on public policy matters and did not seek to influence the content of government policy or regulations. We recognize that many of the issues which we have addressed are matters of considerable public discussion and debate, and that they are subject to public policy and regulation. In seeking to apply information derived from the Task Force's work, however, readers should be aware that there are fundamental differences between the voluntary, multiple-options approach encompassed in the Task Force's recommendations and a regulatory process that carries the force of law.

At the same time, because our intent is to increase demand for environmentally *preferable* paper, we have identified attributes of products, and of the technologies and practices used in making them, that by definition represent advances that extend beyond compliance with regulatory requirements. While we have crafted our recommendations to operate independent of the environmental regulatory system, we consider those controls and other expressions of public policy as providing the minimum level of environmental protection with which we expect all of our suppliers to comply.

Senior managers at each Task Force member organization signed a Memorandum of Agreement that established the Task Force, set out its purpose and scope of work, and delineated operating guidelines to ensure a substantive process and product. Among the key parts of the agreement were provisions stating that all members of the Task Force would pay their own expenses for the project and that the Task Force's recommendations would be implemented individually by the Task Force members. A copy of the memorandum is attached as Appendix A.



II. SCOPE AND PROCESS OF THE PAPER TASK FORCE

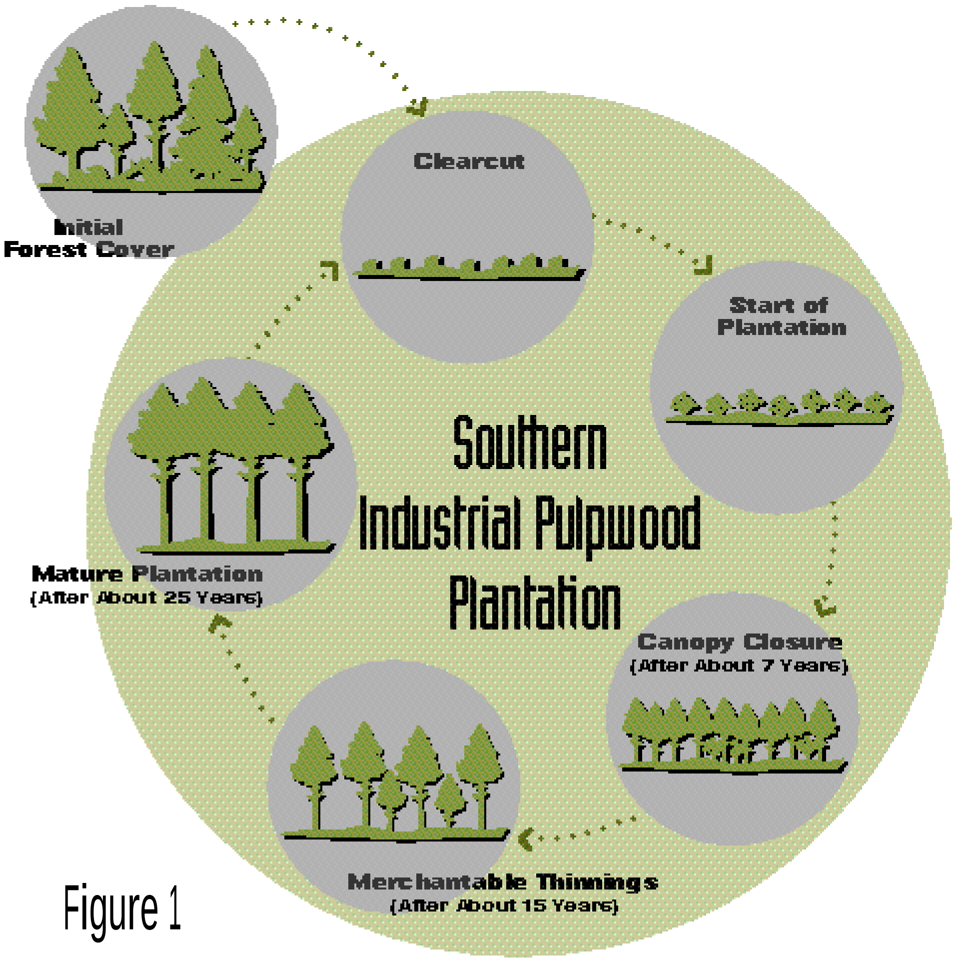


Figure 1

Types of Paper Examined by the Task Force

The recommendations of the Paper Task Force cover three major categories of paper products: printing and writing papers, corrugated shipping containers and folding cartons used to package consumer goods for retail sale. Many different specific types of paper fall within these broad categories, which represent approximately 70% of all the paper used in the United States.

The Paper Task Force's recommendations do not cover newsprint, tissue and toweling products and certain highly specialized uses of paper. We chose this approach at the outset for several reasons. The Task Force does not include any major newspaper publishers. Moreover, several other groups have examined environmental issues associated with newsprint, especially in the area of recycling;[1] partly in response to these efforts, there has already been significant recent investment in recycling capacity by newsprint manufacturers in North America.

While all of the Task Force members buy tissue and toweling products for their businesses, 60% of the U.S. tissue market is in the residential sector and therefore outside the Task Force's primary emphasis on commercial paper use. Commercial and residential tissue products tend to have different performance properties, and the vast majority of the tissue used in commercial establishments already contains recycled fiber, often at the 100% total recycled content level.

The research that provides the foundation for the Task Force's recommendations does analyze the totality of U.S. paper use where appropriate. For example, the Task Force's analysis of the economics of recycling considers the role of recovered paper by recycled newsprint and tissue manufacturers in the overall paper recycling system in the United States. Research on the environmental aspects of paper recycling versus conventional solid-waste management also considers the environmental aspects of collecting newspapers and manufacturing newsprint with recycled content, because these activities are a major part of the current recycling system.

While we caution against applying the Task Force's recommendations in the areas of recycling and manufacturing to the grades of paper that we did not examine, the recommendations on forestry are broadly applicable to any conventional wood-based paper produced in the U.S. For the truly ambitious paper purchaser, the full research and evaluation methodology developed by the Paper Task Force could be used to develop purchasing recommendations for paper grades we did not cover.

Basic Steps in the Paper Lifecycle

This section provides a brief overview of the activities involved in acquiring virgin fiber from forests, transforming that fiber into pulp and paper products, and managing these materials after they are used. The intent is to familiarize the reader with the basic practices and technologies, as well as the associated terminology, in order to facilitate understanding of the Task Force's recommendations.

Virgin Fiber Acquisition: Forest Management

Forest management, or *silviculture*, for the purpose of producing fiber can be viewed on two different scales. The first involves the specific activities carried out on a specific *stand* of trees over the course of a specific time period, called a *rotation*. The second involves the spatial and temporal distribution of silvicultural activities across the many stands that may occur in an area of managed forest. Two major types of silvicultural systems can be distinguished. *Even-aged management* involves stands where virtually all of the trees are of basically the same age, reflecting the fact that all the trees in the stand were harvested, and all of the trees in the new stand were established, or *regenerated*, at approximately the same time. *Uneven-aged management* involves harvesting and regeneration that are spread both spatially and temporally over the stand, thereby resulting in a stand of trees covering a wide range of ages and sizes.

In most silvicultural systems, activities conducted in a given stand over the course of a given rotation may include road construction, maintenance and use; harvesting; site preparation; regeneration; stand tending and protection; and thinning. At the end of the rotation, the stand is harvested and the cycle begins again. For each activity, a variety of methods may be used, depending on the character of the specific site, the tree species and other values being managed for, and the overall intensity of management. Figure 1 illustrates the stages of a typical southern pine plantation rotation. More detail on these activities and their associated impacts is provided in Chapter 4 and in White Papers Nos. 4 and 11.

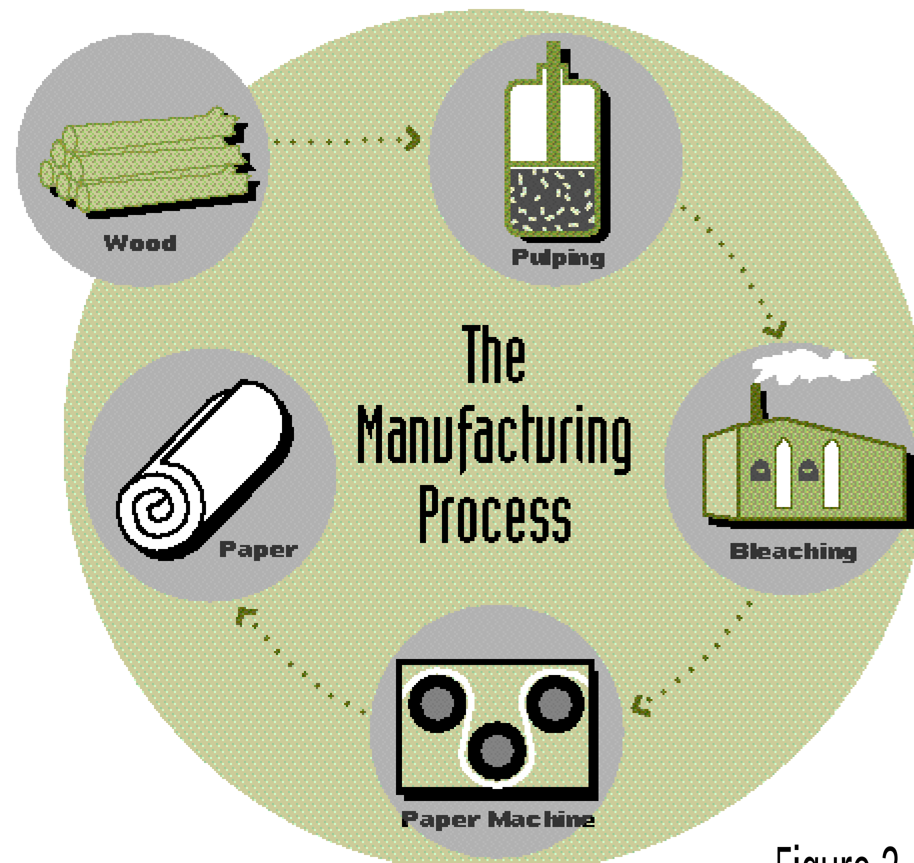


Figure 2

Pulp and Paper Manufacturing

Transforming cellulose fibers (whether from wood or other plants, or from recovered waste paper) into paper consists of three basic steps. First, the raw material is *pulped*. Pulp mills use mechanical or chemical processes, and sometimes a combination of the two, to break up the fibers and separate them from unwanted materials. In mechanical processes, the fibers are physically separated from each other, while in chemical processes, the fibers are also separated from lignin (the "glue" that holds the fibers together in wood). Second, if needed to produce a white pulp used in many paper products, the pulped fibers are chemically *bleached* in a multi-step process. A variety of chemicals may be employed in bleaching, including the elemental form of chlorine or other chlorine compounds such as chlorine dioxide, and oxygen-based chemicals such as hydrogen peroxide or ozone. Finally, the bleached or unbleached pulp is spread in a thin layer, pressed and dried on a paper machine to make paper.

Each of these steps is illustrated in Figure 2. While cellulose fibers account for the bulk of paper, some paper products also incorporate coatings, fillers or other additives to impart desired qualities. Water is an important component at all stages of the papermaking process because it carries the fibers through each step.

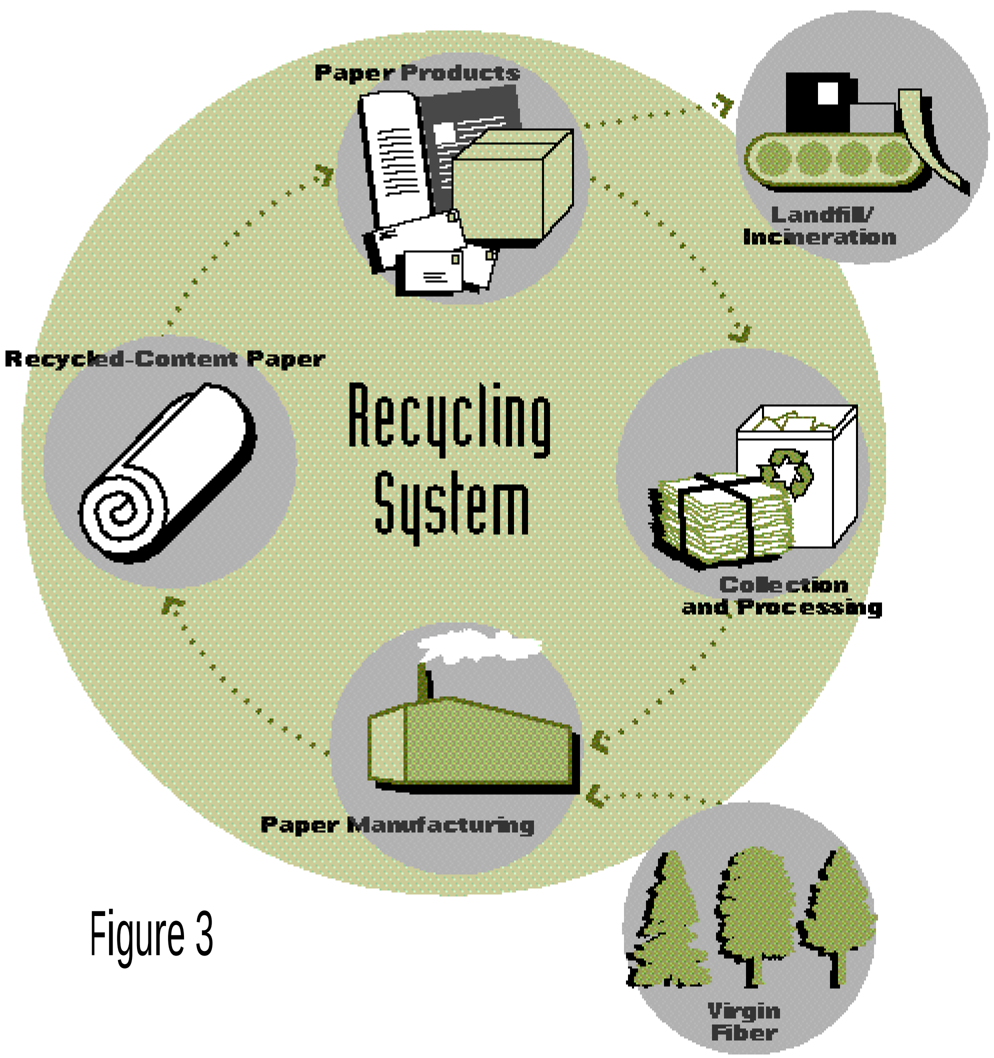


Figure 3

Recycling and Waste Management

Depending on one's perspective, the practice of recycling represents both an alternative source of fiber for making paper, and an alternative to traditional means of solid-waste management, such as landfilling and incineration. The paper recycling process has several steps, illustrated in Figure 3. First, used paper must be segregated and *collected* separately from solid waste. This step is usually the responsibility of the business or household that generates the used paper and other recyclable items. In some cases, recycling collectors or solid-waste haulers will pull recyclable paper from clean loads of mixed commercial waste, typically from offices. The next step is *processing*, which usually means some form of sorting of loose paper to remove obvious large contaminants, and then baling the paper for efficient transportation and storage. Finally, the recovered paper is cleaned and processed at a mill and made into pulp suitable for *manufacturing* new paper products. The nature of this fiber-cleaning stage depends on the type of paper being made. For example, recovered paper used in making new printing and writing paper, tissue and newsprint is deinked, while recovered paper used to make paperboard usually undergoes less extensive processing.

Managing discarded paper as solid waste instead of recycling it involves collecting refuse in conventional "garbage trucks," sometimes transferring the waste to larger trucks or railcars at a transfer station for shipment, and landfilling or incinerating the material. Landfilling generates by-products such as landfill gases and leachate, while combustion in an incinerator produces a variety of air emissions and ash residue, which must be landfilled.

The Task Force's Research Process

Over the course of more than two years of research, the Task Force assembled a body of information that is unique in its depth and scope. We spent roughly equivalent amounts of time and effort examining three issues related to paper use, including:

- The key *performance characteristics* of various grades and uses of paper, and how such functional properties can be affected by changes in the fiber source or the processes used to make the paper.
- The *environmental impacts* associated with all parts of the life-cycle of paper, literally from the forest to the landfill.
- The *economics* of paper use, including the cost of producing wood, recovered fiber, pulp and paper products, and the dynamics of market pricing for these various commodities.

By carefully integrating information on functionality, environmental issues and economics, the Paper Task Force sought to maximize the likelihood that our recommendations will be implemented, thereby effecting environmental gains.

From the beginning the Task Force's approach to developing its recommendations was grounded in thorough technical research. In January 1993, the Task Force held its first meeting which included a basic overview of pulp and paper manufacturing provided by the Department of Pulp and Paper Science at North Carolina State University. The Task Force's second meeting, in February 1993, included a tour of a major printing and writing paper mill.

After the Task Force was formally announced to the public in August 1993, we conducted a series of introductory and technical visits with more than a dozen pulp and paper companies that are major suppliers to Task Force members, as well as universities and other research institutions. Many of these meetings also encompassed visits to pulp and paper mills, recycling centers, experimental and working forests, and laboratory facilities. Technical discussions and dialogue were held that covered the full range of research topics being examined by the Task Force. In many cases, follow-up meetings and telephone conversations provided the Task Force with additional information.

In its research process, the Task Force gathered data from a very broad range of sources. We actively solicited information from experts in the pulp and paper industry, consulting firms, the environmental and financial communities, graphic designers, office equipment manufacturers, printers, forms converters and university research institutions. The Task Force also reviewed a wide range of published literature, including trade publications, analyses provided by individual paper companies and trade associations, consultants' reports, government documents, technical manuals, conference proceedings and peer-reviewed scientific papers. Finally, we tapped the considerable experience and expertise of Task Force organizations themselves.

In order to hear directly from experts and identify areas of agreement or controversy, the Task Force convened 10 expert panel discussions, in which four to six individuals representing different organizations responded to questions posed by the Task Force. For each of these expert panels, the Task Force developed an "issue paper" to provide key background information. These issue papers were circulated for external expert review. Panel members and expert reviewers were selected to cover the full range of expertise and perspective on a given issue and to ensure balance. The members of each panel and the topics they discussed are listed in Appendix B.

The Task Force then integrated all of the information gathered through the research meetings, site visits, expert panels and comments on issue papers into 16 more detailed, fully referenced White Papers on specific topics. The White Papers identified key findings of our research, and these findings served as the foundation for our recommendations to purchasers.

The Task Force distributed the White Papers for expert review and solicited written comments from a range of individuals and organizations with expertise on given topics. Task Force working groups carefully reviewed all the comments and revised the papers to reflect new information received. In many cases, Task Force members engaged in further dialogue with reviewers to ensure a full understanding of issues they had raised or new information they had submitted. The Task Force's White Papers, listed on the next page, comprise Volume II of the Task Force's final report.

White Papers

Paper Task Force White Papers Listed by Topic Area

- **Paper Performance**
  - – Functionality Requirements for Uncoated Business Papers and Effects of Incorporating Postconsumer Recycled Content (White Paper 1)
  - – Functionality Requirements for Coated and Uncoated Publication Papers and Effects of Incorporating Postconsumer Recycled Content (White Paper 8)
  - – Functionality Issues for Corrugated Packaging Associated with Recycled Content, Source Reduction and Recyclability (White Paper 6A)
  - – Functionality Issues for Folding Cartons Associated with Recycled Content, Source Reduction and Recyclability (White Paper 6B)
- **Recycling and Used Paper Management**
  - – Economics of Recycling as an Alternative to Traditional Means of Solid Waste Management (White Paper 2)
  - – Lifecycle Environmental Comparison - Virgin Paper and Recycled Paper-Based Systems (White Paper 3)
  - – Economics of Manufacturing Virgin and Recycled-Content Paper (White Paper 9)
- **Forest Management**
  - – Environmental Issues Associated with Forest Management (White Paper 4)
  - – Economic Considerations in Forest Management (White Paper 11)
- **Pulp and Paper Manufacturing**
  - – Environmental Comparison of Bleached Kraft Pulp Manufacturing Technologies (White Paper 5)
  - – Economics of Kraft Pulping and Bleaching (White Paper 7)
  - – Environmental Comparison - Manufacturing Technologies for Virgin and Recycled-Content Printing and Writing Paper (White Paper 10A)
  - – Environmental Comparison - Manufacturing Technologies for Virgin and Recycled Corrugated Boxes (White Paper 10B)
  - – Environmental Comparison - Manufacturing Technologies for Virgin and Recycled Coated Paperboard for Folding Cartons (White Paper 10C)
  - – Comparison of Kraft, Sulfite and BCTMP Pulp and Paper Manufacturing Technologies (White Paper 12)
  - – Non-wood Plant Fibers as Alternative Fiber Sources for Papermaking (White Paper 13)

As the Task Force began to develop its recommendations, we again convened meetings with key stakeholders and experts drawn from members' suppliers, the American Forest & Paper Association, academic researchers and environmental organizations. These meetings were designed to provide additional guidance and perspective on the form and content of the Task Force's recommendations before we began to draft them. The Task Force then drafted its recommendations independently.

Overall, the Paper Task Force held approximately 400 meetings with representatives of over 120 different organizations. In this process we visited over 50 manufacturing, recycling, forestry and research facility sites. The success of the Task Force is due in large part to the extraordinary cooperation and effort of a wide range of parties. We have listed the organizations we met with and their contribution to the process in the Acknowledgments, at the beginning of this report.

Research Approach for Functional, Environmental and Economic Issues

Approach to the Functionality Research

Purchasers must be confident that the paper products they buy will meet a range of performance requirements, including print-quality standards and runability in equipment such as photocopy machines, printing presses and package-filling lines and distribution systems. Understanding the functional requirements of various paper and paperboard grades was therefore a critical element of the Task Force's analysis.

In one of the first steps in the Task Force's research process, members gathered qualitative and quantitative information on their organizations' purchasing and use of paper, and on their used paper recycling or disposal practices. These *paper use inventories* provided an information baseline to help Task Force members identify the specific uses and quantities of paper in their organizations, performance requirements, existing purchasing specifications and relevant supplier information.

The Paper Task Force's goals in researching the performance requirements associated with various grades of paper were to: (1) identify the attributes of certain paper grades that enable them to perform as intended; (2) analyze the relationship between the raw materials used to produce paper and the requirements of the papermaking process; and (3) understand how equipment specifications drive a given product's specifications.

The Task Force defined paper "functionality" as the ability of a sheet (or roll) of paper to meet the purchaser's expectations for running in required equipment and machines to create the desired end product. In particular, the Task Force examined how the incorporation of recycled content affects the performance of specific grades of printing and writing paper, corrugated boxes and folding cartons. The specific performance requirements and physical properties of business communication papers, publication papers, corrugated boxes and folding cartons that are critical to meeting the needs of end users are described below in Section III. The Task Force's findings on the performance of recycled-content grades are summarized in Chapter 3 of this report; further detail can be found in White Papers Nos. 1, 6A, 6B and 8.

Approach to the Environmental Research

In identifying environmental preferences, the Task Force adopted a broad, systematic view of the issues involved, rather than considering only a single or a few attributes of paper — its recycled content, for example, or how it is bleached. The Task Force constructed a set of analytical tools that allow different types of paper to be compared on an environmental basis across their full lifecycle, including: (1) how the fiber used to make paper is acquired, whether from a forest or a recycling collection program; (2) how that fiber is manufactured into a range of paper products; and (3) how those products are managed after their use, whether in landfills or incinerators or through collection for recycling. In using this approach, the Task Force has provided a way for purchasers to address all of the major environmental impacts of their paper use.

The decision framework set out in the Project Synopsis that opens this report reflects the comprehensive scope of the Task Force's environmental research. In sum, reducing the use of paper generally provides major environmental benefits, but even after aggressive use-reduction measures, businesses will still use significant quantities of paper. Using paper with recycled content also provides comparative environmental benefits in the areas of forest management, pulp and paper manufacturing, and solid-waste processing and disposal. However, there are ultimately functional and economic limits to the amount of recycled material that can be used in paper on an aggregate basis. It is important to examine opportunities to reduce the environmental impacts associated with the acquisition of virgin fiber through forest management and with the manufacturing of virgin pulp and paper. The research of the Paper Task Force provides paper purchasers and users with the capability to investigate and make progress in all of these areas.

The basic research of the Task Force on environmental issues is contained in White Papers Nos. 3, 4, 5 and 10 A, B and C, and the results of these analyses are summarized in Chapters 3, 4 and 5.

The inclusion of *forest management* activities in our overall analysis — and its direct linkage to purchasing considerations — is an example of the thoroughness of our approach. Most other studies of paper products, including virtually all lifecycle assessments conducted to date, draw the "upstream" boundary of their analyses *after* the forest: In essence, they assume a given quantity of wood as an input into the product system being studied, without considering the environmental and economic consequences of activities required to produce that wood. The biological and ecological character of the impacts of forest management activities does not allow a direct or quantitative comparison to other measures of environmental impact — for example, energy use or releases of air emissions from a manufacturing facility. To omit such impacts entirely from an assessment of paper products, however, produces a greatly distorted picture. Instead, we have included a full assessment and description of such impacts, and through our recommendations have given paper users the means to use this information in their purchasing decisions — whether in considering the relative merits of recycled vs. virgin fiber content or in identifying preferences among different management practices used to produce virgin fiber.

In the area of *pulp and paper manufacturing*, the Task Force undertook two types of comparative analyses. First, we compared the environmental profiles of a range of existing pulping and bleaching technologies used to produce virgin pulps and paper products. These technologies include mechanical as well as chemical pulping processes and, among the chemical processes, those yielding unbleached pulp as well as pulp bleached using a range of different bleaching agents. Second, for several different grades of paper, we compared the environmental profiles of manufacturing processes using virgin fiber to those that use recycled fiber.

Both types of analysis base the comparison of technologies and products on the relative magnitude of the following parameters:

- energy use, including both total energy requirements and those met by the purchase of fuels or electricity[2]
- water use or quantity of effluent discharged
- emissions of several major categories of air pollutants
- releases of several major categories of waterborne wastes
- quantity of solid-waste output.

In the area of *managing paper after it is used*, the Task Force compared the environmental profiles of the major methods employed in the United States today: landfilling of municipal solid waste (MSW) containing used paper (employed to manage 53% of used [postconsumer] paper); incineration of MSW containing used paper in waste-to-energy facilities (13%); and collection and processing of used paper for purposes of recycling (34%).[3] The same parameters (excluding water use) described above served as the basis for comparison of the three methods.

Finally, for the purpose of providing a comprehensive view of the comparison between virgin and recycled fiber, the Task Force assembled a quantitative model that combined the data for manufacturing virgin and recycled paper in various grades with the data for the various methods employed to manage used paper. In this way, three essentially complete "systems" can be directly compared:

- *Virgin production plus landfilling:* acquisition of virgin fiber[4] and manufacture of virgin paper, followed by landfilling.
- *Virgin production plus incineration:* acquisition of virgin fiber and manufacture of virgin paper, followed by incineration.
- *Recycled production plus recycling:* manufacture of recycled paper, followed by recycling collection, processing and transport of used paper to the site of remanufacture.[5]

The Task Force assembled such data for each of several grades of paper: newsprint, uncoated freesheet printing and writing papers, corrugated boxes, and coated paperboard used to make folding cartons.

The Task Force's environmental comparison of different paper manufacturing and disposal/recycling systems is based primarily on estimates of the *quantities* of energy used by, or environmental releases from, certain processes or facilities. In these comparative assessments, the Task Force has not attempted to assess the magnitude of environmental *impacts* — for example, effects on the health of humans or wildlife — that arise from the associated energy use and environmental releases. Actual environmental impacts caused by the release of specific chemical compounds, for example, depend on site-specific and highly variable factors such as rate and location of releases, local climatic conditions, population densities and so on, which together determine the level of exposure to substances released into the environment. To conduct such an assessment would require a detailed analysis of all sites where releases occur, a task well beyond the scope of this project and virtually any analysis of this sort.

In a larger sense, reducing the magnitude of energy use or environmental release will represent a genuine environmental improvement in the vast majority of cases. Indeed, the widely embraced concept of *pollution prevention* is based on the sound tenet that the avoidance of activities linked to environmental impacts is far preferable to seeking to moderate the extent of impacts after the fact. In the absence of definitive evidence to the contrary, purchasers can feel confident that expressing a preference for technologies or practices that reduce the magnitude of environmental releases or energy use will benefit the environment.

In general, the data cited and presented in this report represent average (mean) values, or estimates otherwise intended to be representative of the facilities and activities being characterized. The environmental characteristics of individual pulp and paper mills, solid-waste management facilities, recycling systems, etc. will almost always vary from the average for a particular class of facilities. In most cases, however, average data are most appropriate for our purposes, because we are most interested in comparing *typical* activities and facilities, not best-case or worst-case ones. In some cases, the Task Force has selected subgroups of facilities where clear and definable differences exist in the average characteristics of the subgroups. For example, the Task Force's analysis of energy use and environmental releases from bleached kraft pulp manufacturing processes is based on several distinct subclasses of both modern and traditional bleached kraft pulp mills.

In cases where a paper user is purchasing through a distributor or retailer and does not have specific information about where the paper was made, the use of averages in an environmental comparison is not only appropriate, but is in fact the only approach to identifying environmental preferences. Purchasers in this situation who make decisions based on averages will, in the aggregate, select environmentally preferable paper products.

In other cases, large paper purchasers buy directly from manufacturers and potentially have access to much more specific data on the environmental attributes of individual facilities. While gathering and interpreting these data is not necessarily a simple exercise, the Task Force's recommendations and implementation options are designed to help major purchasers of paper get started, through an informed dialogue with their suppliers. In these cases, facility-specific data can be compared to the average or typical values provided in this report. Hence, the data presented here are useful as a starting point in indicating general or likely attributes, and can be subjected to further examination and confirmation if applied to a more specific situation.

As a final note, the approach adopted by the Task Force of comparing activities or processes based on the average magnitude of key environmental parameters is a widely accepted method employed in virtually all similar lifecycle assessments, including those conducted or commissioned by private companies in a broad range of business sectors (including pulp and paper manufacturing) and by government agencies.

Approach to the Economic Research

Economic considerations in paper purchasing and use were central to the Task Force's research and to the development of our recommendations. This research considered both the *cost* of manufacturing environmentally preferable paper, and the *price* of different grades of paper in the marketplace.

Several strategic goals are embodied in the Task Force's analysis of economic factors in paper purchasing and use. Prices for paper products rise and fall over time based on market supply and demand, but over the long term are also related to manufacturing costs. While purchasers are concerned in the short term with paper prices, over the longer term it is to their advantage to align themselves with paper producers who employ environmentally protective and efficient practices and technologies. The Task Force's recommendations are also sensitive to the importance of the timing of investments by paper suppliers, the fact that these investment are usually long-lived, and the fact that paper-pricing cycles influence the ability of purchasers to implement some recommendations at certain times.

Major paper users will benefit over the long term if suppliers are financially healthy enough to be able to modernize their practices and technologies and invest in research and development on new practices, technologies and products. Paper purchasers also have an incentive to examine the specifications for their paper closely, in part to ensure that the type of paper being purchased is not over-specified for its true performance requirements. The Task Force believes that these steps are consistent with continuous improvement in environmental performance.

> Economic considerations in paper purchasing and use were central to the Task Force's research and to the development of our recommendations.

The basic research of the Task Force on economic issues is contained in White Papers Nos. 2, 7, 9 and 11, and the results of these analyses are summarized in Chapters 3, 4 and 5.

At the outset of this project, the Paper Task Force established a set of guidelines for conducting economic research that would allow for a detailed, insightful investigation, but would not raise concerns regarding the use of proprietary data or anti-trust issues. These guidelines were reviewed by specialists in anti-trust and business law retained by the Environmental Defense Fund, and by counsel within Task Force member organizations, and were followed by the Task Force throughout the process.[6] There are a number of additional factors inherent in the design and composition of the Task Force that significantly reduce anti-trust concerns.[7]

To eliminate or reduce the need to use proprietary information, the Task Force's research guidelines placed a priority on using the following types of data sources:

- Public reports such as paper industry technical papers and government documents.

- Data provided by trade associations (which have access to data that they aggregate from individual companies for public use).
- Models provided by consulting firms that aggregate data from empirical sources or provide estimates based on engineering and economic calculations.
- Models developed by the Task Force that can be reviewed by paper manufacturers or others to verify their accuracy without requiring disclosure of information on the part of the reviewer.
- Historical market price information provided by public sources (for example, industry newsletters).
- General cost estimates developed by equipment suppliers.
- General or aggregated cost estimates developed by individual paper suppliers or Task Force members; these are expressed in any of three forms: (1) to indicate the direction and magnitude of a change from a baseline case, (2) to express a range or (3) as estimates for a "generic" case.

In its economic research, in addition to using data from all of these types of sources, the Task Force worked with two leading paper industry consulting firms, to obtain data on recovered paper market price forecasts, market pricing for new paper products and paper manufacturing costs.[8]

In several cases, the Task Force developed detailed hypothetical models that estimated changes in paper manufacturing or wood production costs under different scenarios related to the Task Force's recommendations. The assumptions and calculations in these models were reviewed by a wide range of industry experts during the White Paper review process, and were modified based on reviewers' comments. In several cases, the Task Force also compared the results from the scenarios expressed in the models to historical and/or known data from actual forest management practices and paper mills.

The models developed by the Task Force often produced estimates for "average" facilities. The use of an average estimated cost for employing a specific practice or investing in a particular type of technology, such as a deinking plant, implies that there are producers who, in making actual investments, will spend either more or less than the projected average. The Task Force's recommendations fundamentally differ from regulations that automatically apply to all paper producers regardless of cost or timing of investment. Therefore, continuing the deinking example, individual paper mills for which the installation of recycling equipment would be higher than the average would likely not be the first to respond to the Task Force's recommendations. Indeed, a large paper producer who operates numerous mills would most likely respond to market demand by adding recycling systems at mills where the costs to do so would be *below* the average — which could be due, for example to the presence of existing equipment. Discussions of "average" or "typical" costs as affected by the Paper Task Force's recommendations should be seen in this light.

III. KEY FINDINGS ON FUNCTIONAL REQUIREMENTS FOR VARIOUS GRADES OF PAPER

The specific findings from the Task Force's research on environmental and economic issues in the areas of source reduction, recycling, forest management and pulp and paper manufacturing are summarized in the Project Synopsis and expanded upon in Chapters 2 through 5, as are several specific issues in the areas of functionality. However, most of the findings from the Task Force's research on functionality apply to the whole body of the recommendations and supporting material. These findings are summarized below.

The performance requirements of the different types of paper products studied by the Task Force vary substantially among different grades, and are summarized in the following sections.

Business Communication Papers

The functional specifications for business communication and publication papers are driven by customers' expectations, the end use of the product, limitations of the papermaking process and the requirements of office machines (particularly photocopiers) and printing presses in which they will be used. Critical to these grades is runability, which refers to the paper's ability to withstand the stresses of copiers, printing presses and subsequent binding and converting operations. Only a few rigorous, systematic photocopier runability tests have been conducted for business and publication papers. Therefore most of the information presented on the performance of recycled-content paper in office machines and offset printing presses is based upon the experience of major equipment manufacturers, paper manufacturers and end users.

Copy paper is designed to perform in high-speed copy machines that subject it to intense heat, pressure, friction, mechanical decurling, electronic charges and contact with other parts of the equipment (sorting bins, binders, etc.). Copier equipment may perform various finishing operations such as folding, stapling, stitching and punching. Color copiers also demand paper durability and performance. This is largely due to the four-pass process, which subjects the paper to toner four times. Electronic (laser) printers and ink-jet printers are common in offices. Mechanically their processes are similar to, though simpler than, those of photocopiers: Laser printers have shorter paper paths and fewer belts and rollers; ink-jet printers have fewer moving parts than photocopiers, and color can be applied in a single pass. Business papers used for envelopes, labels and forms must withstand the stress associated with being transported through high-speed converting operations.

To meet these performance demands and print-quality standards, the most important physical properties for uncoated business papers are strength, stiffness, proper moisture content, smoothness, dimensional stability, ink/toner receptivity and absence of lint.

Publication Papers

In researching the functional requirements of publication papers, the Task Force primarily focused on lithographic offset printing because it is the dominant method used to print magazines, books and other commercially printed products. In 1993, 76% of the magazines published in the United States were produced via offset printing.[9]

Publication paper grades must withstand the tensions of rollers, pressure of the blanket, moisture added by the application of fountain solution and ink, and heat applied during the drying phase. Put more graphically, in a typical offset press, paper is stretched and contracted, moistened with water and ink, heated from room temperature to 300° F in less than three-quarters of a second, and then cooled to below 100° F in less than a second. Publication papers must also withstand subsequent finishing or postpress operations such as binding, gluing and converting. An advantage to offset printing is that less wear and abrasion occur to the equipment than with other processes (such as photocopying) because paper does not contact the plates.

The most important paper properties for runability in offset printing equipment and converting operations are: tensile and tear strength, cleanliness, smoothness, pick resistance and consistency from roll to roll. Essential to in-line finishing operations (for example, folding, binding, die-cutting, cutting, trimming, scoring, gluing and perforating) are burst strength, uniform caliper and basis weight, and stiffness. Printers also seek consistency in paper from roll to roll so that they can plan for and predict how a project will perform on press.

The important properties for print quality are opacity, porosity, flatness, cleanliness, shade and a smooth surface. Brightness is a major specification for many publication papers, and is the primary method of classification for coated paper grades. Brightness, gloss and type of finish are particularly important in multi-color printing on coated paper. Bulk, an important specification for book papers, is driven by the product's end use for two reasons: Bulk contributes to the "feel" of book paper and also affects opacity; and for some books, the publisher prefers high-bulk paper to give the appearance of more pages. Permanence is usually an important property, especially for archival books.

Some specifications for uncoated publication papers are less stringent than those for the base stock of coated papers. Paper that is not coated is subjected to less contact with water in the manufacturing process than coated grades are, which means that the specifications for tensile and tear strength may not be as stringent. In addition, brightness specifications may be lower for uncoated groundwood than for uncoated and coated freesheet because the high percentage of mechanical pulp in groundwood papers lowers their brightness capability. The requirements for cover papers may vary because cover papers can be uncoated or coated; some may have color or various finishes.

The requirements for the surface properties of the base stock usually are more stringent for coated than for uncoated papers. For both virgin and recycled-content paper, the coating process presents challenges. Coaters operate at very high speeds. Any defect in the base sheet or loose contaminants on the surface can cause a web break on the coater or streaks and scratches, resulting in downtime to clean up and restart the machines.

The paper properties most important in determining the nature and uniformity of the coating layer are the surface properties (for example, smoothness, finish, ink absorption), strength and optical properties (for example, opacity, brightness) of the base stock. Other factors that affect the coating process are the composition of the coating, the method of coating, the method of drying and the extent of supercalendering.

Corrugated Boxes

To determine functional requirements for corrugated boxes, the Paper Task Force considered two types of distribution systems: shipments in corrugated boxes in bulk and single-package shipments. In the first environment, a set of boxes typically is transported from a manufacturer to a warehouse or a point of sale by truck or rail. In the second environment, single boxes are transported from a manufacturer to individual destinations by a small parcel carrier. The types of box specifications used are similar in both environments. However, when boxes are shipped in bulk by rail or third-party trucking companies, box purchasers must adhere to more specific and detailed box performance criteria as outlined by the American Trucking Association (National Motor Freight Classifications) or the National Freight Railroad Committee (Uniform Freight Classifications).

In both distribution environments, major functional requirements for boxes are box strength, runability on automated packaging machines and/or automated parcel-processing systems, consistency of performance and box appearance. The last requirement is gaining importance, because more products packaged in corrugated boxes have reached the end consumer.

Among the above criteria, box strength is clearly the most important. Boxes must hold goods and bear up during transportation and when stacked during warehousing. Basis weight and burst strength were the traditional box strength specifications. While these are still important, many box purchasers have shifted to compression strength as an alternative measure (either Edge Crush Test [ECT] for the corrugated board or box compression for the entire box). This shift is a result of new product developments in the containerboard industry. High-performance containerboard has been developed to add compression strength while increasing recycled content and/or reducing the weight of the board. The shift has also been facilitated by an adaptation of the box strength characteristics in the National Motor Freight Classifications.

Folding Cartons

Folding cartons are paperboard boxes that are creased and folded to form containers that are generally shipped and stored flat and then erected at the point where they are filled. Folding cartons are designed to contain and present products in a retail setting, and are generally small enough to hold in one hand.[10] The three major grades of paperboard used to make folding cartons are solid bleached sulfate (SBS), coated unbleached kraft (CUK)[11] and clay-coated recycled paperboard. These three types of paperboard differ in their manufacturing processes, functional properties and price. The Paper Task Force has focused its recommendations on folding cartons that do not come into direct contact with fatty or aqueous foods, due to the much larger market share for packaging that does not have direct contact with food.

Users of folding cartons are generally concerned with three criteria for the boxboard: appearance, strength and machinability (the ability of the carton to set up and run smoothly and quickly through packaging filling lines). Folding cartons must meet performance requirements through their entire use cycle, including converting and printing, filling and gluing, distribution, retail presentation and use by the final customer. Packaging buyers tend to specify performance criteria for the overall package, rather than for the paperboard used to make the package.

Because folding cartons are used to present products to the consumer, appearance is critical. The most important visual criteria for finished folding cartons relate to its printability, and include smoothness, ink receptivity, ink holdout, rub resistance, coating strength, ink and varnish gloss and mottle resistance.[12] Brightness, cleanliness, gloss and the absence of debris or loose fiber are also important attributes.[13] Not all criteria are important for every printing technique.

The most important measurement of strength for folding cartons is usually stiffness.[14] Other measures of package strength include tear strength, compression strength, burst strength and moisture resistance. Strength *per se* is not as critical for folding cartons as it is for corrugated boxes.

Machinability depends on the type of filling and gluing machines being used as well as on the boxboard. Machinability is most critical in a challenging filling environment (for example, beverage filling lines tend to create wet and humid conditions) or when the speed of the filling line is a critical factor in determining the overall production-line speed for the product. Conventional filling machines are fairly flexible and can be tuned to compensate for the properties of different types of board.

IV. THE ECONOMIC STRUCTURE OF THE PULP AND PAPER INDUSTRY AND ITS RELATION TO PAPER PURCHASING

Paper users will be better equipped to make purchasing decisions that help the environment and to reduce costs or maintain cost parity if they understand the economic consequences of their actions and the economic structure of the paper industry. A fundamental part of the Paper Task Force's research was consideration of the basic economic features of paper production and use, and these are summarized in this section. Additional information on economics is integrated throughout both volumes of this report.

Capital-intensive Manufacturing

Selling paper is a commodity business. Although paper manufacturers strive to differentiate themselves through quality and service, price remains a dominant factor in paper users' purchasing decisions. As purchasers know well, paper pricing is highly cyclical. When the Paper Task Force began its work in 1993, nominal prices for major grades of paper were at a postwar low. In mid-1995 the situation was completely different; by late 1995, however, prices for some grades had begun to soften.

Paper manufacturing is the most capital-intensive major manufacturing industry in the United States.

These features of paper markets have their roots in several specific aspects of the economics of paper production and use. Demand for paper is strongly correlated with general economic growth, and it fluctuates with the business cycle. In percentage terms, paper shipments decline further than overall economic activity during recessions.

Paper manufacturing is also the most capital-intensive major manufacturing industry in the United States. For example, it takes twice as much investment in real estate, plant and equipment to produce one dollar's worth of paper as it does to produce one dollar's worth of cars. With an increased pace of technological development, the capital intensity of the paper industry has grown over time.[15] Capital expenditures in the paper industry in 1991 were $9.0 billion, or 8% of net revenues.[16]

A long-term trend in the U.S. paper industry is that production of commodity-grade paper in particular is moving to larger and larger mills located in the southern United States. Two-thirds of the growth in U.S. paper production from 1970 to 1992 occurred in the South. By 1992, 74.8% of pulpwood consumption, 35.6% of recovered paper consumption and 55.1% of total paper and paperboard production was based in the South.[17]

Paper producers have also been making ongoing and continuous investments to make their mills more productive. For example, between January 1983 and January 1993, paper manufacturers installed new paper machines or significantly renovated existing machines accounting for 57% of overall U.S. manufacturing capacity. Among paperboard mills, the total new or renovated capacity installed in the same period was even higher, especially for linerboard and solid bleached sulfate.[18] As a result of all this investment, manufacturing costs have fallen in real terms since the early 1970's. As mills have reduced their real dollar costs, competition has driven the average price of paper through the cycle downward in real terms.

The investments required to build pulp and paper mills are enormous. In the mid 1990's an integrated bleached kraft pulp and paper mill making 1,500 tons per day of white paper will cost roughly $1 billion. Renovations of 1,000-ton-per-day kraft pulping and bleaching lines now cost on the order of $500 million, and 300-ton-per-day recovered-paper deinking plants cost $100 million or more. Paper manufacturers compensate for these high capital costs through economies of scale — that is, production in large volumes. New machines currently being installed in the United States to make uncoated freesheet paper will produce more than 360,000 tons per year (tpy), enough paper to supply well over one million office workers.[19] As paper mills have become larger and more complex over the last 25 years, the ratio of fixed (capital) costs to variable and semi-variable costs at the average mill has risen. Paper companies have also taken on more debt in order to build new facilities, renovate existing mills or finance acquisitions.[20]

The overall push to replace more expensive variable cost factors with less expensive and more predictable capital equipment has reduced labor costs substantially. Throughout the U.S. pulp and paper industry as a whole, consolidation of companies and a trend toward larger paper machines eliminated 20,800 manufacturing jobs from 1980 to 1989, while overall production increased 27%.[21] At the same time, the 623,000 remaining manufacturing jobs in the pulp and paper industry are generally positions that require highly skilled workers, and that pay on average 25% more than the average manufacturing job.[22]

Capacity and Price Cycles

Papermakers tend to build new manufacturing capacity in cycles, after accumulating cash reserves in profitable periods. The very large size of modern pulp and paper mills and the cyclical nature of capital spending means that new production capacity tends to arrive in waves. For major expansion of virgin pulping facilities or the addition of new paper machines, the period of planning through construction takes roughly five years. Over the last 25 years, this has meant that large increments of new capacity tend to arrive well after the peak of the price cycle has passed, and often during recessions. This is especially true for virgin market pulp.

These combined factors — capital intensity, general swings in the economy, capacity building cycles, the tendency to add capacity during recessions and the fact that new production capacity comes on in large blocks while changes in demand can be more gradual — produce wide fluctuations in the market price of paper, in cycles lasting roughly seven years.[23] For example, four large virgin uncoated freesheet (UCFS) machines with a total annual capacity of 1.1 million tpy, or 8.8% of total existing capacity, came on line in 1990 and 1991. This capacity was being planned in 1987 and 1988 when UCFS prices were rising and operating rates hovered around 93-94%. With the introduction of so much new capacity from September 1990 to September 1991, operating rates dropped to 88% and prices fell dramatically.[24]

At high operating rates, paper mills have declining marginal costs for some factors of production. For example, in the case of labor, it takes roughly as many people to run a machine at 95%

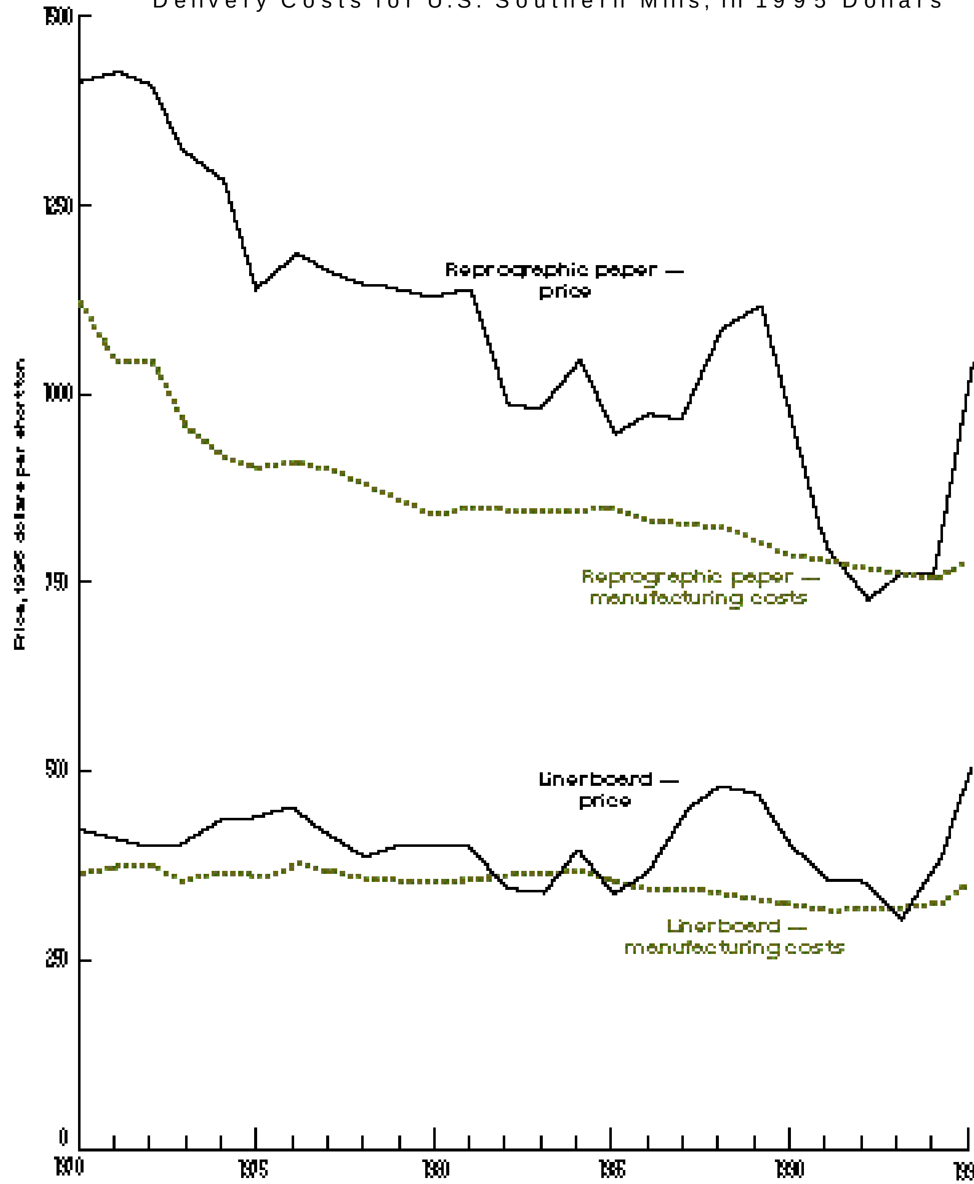
of capacity as it does at 85%, but at the higher operating rate, the same labor costs are spread out over more tons of production. Energy costs per unit of output for pulp and paper dryers also decline somewhat as production increases. Combined with high capital costs, which do not vary with operating rates, these factors create an incentive for paper mills to run their pulping systems and paper machines at full-capacity; as a general rule, integrated virgin pulp and paper mills must run at or above 90% capacity on average to make a profit.

As prices head downward at the beginning of a decline, mills behave differently depending on their cost structures. In general, large, low-cost producers cut prices in order to maintain market share and keep their machines running at full capacity. If necessary, they will drop prices all the way down to the level of their variable costs. In this situation they will maintain cash flow in order to cover their variable costs and make some contribution toward their fixed costs. As prices get very low, the high-cost producers take machines out of production. When market prices are lower than mills' variable costs, it does not make economic sense to operate. In the severe downturn of 1991-1993, numerous high-cost market pulp mills and newsprint machines took extended furloughs. In this way, production is ultimately balanced with demand, and the stage is set for a recovery in paper prices.

Upturns in paper pricing tend to lag behind the general economy, but if the previous down period has been especially extreme and if a good deal of capacity has been furloughed or retired, or if expansions have been deferred, the rebound in prices can be very pronounced. The effect of increasing capital intensity and the concentration of production at large, modern facilities with generally similar costs means that the difference between the peaks and valleys in the pricing cycle is becoming greater over time. During periods when the supply of paper is greater than demand, a greater fraction of the industry will compete and drive prices down to very low levels in order to keep running. When growth in the economy catches up with paper production and demand begins to exceed supply, there is little extra capacity that can be brought on-line quickly. Paper is often allocated among different users essentially based on their willingness to pay higher prices for it, or based on past customer history.

Figure 4

20-pound Cut-size Reprographic Paper and 42-pound Standard Linerboard; Average U.S prices and Average Manufacturing plus Delivery Costs for U.S. Southern Mills, in 1995 Dollars



Source: Resource Informations Systems, Inc., 1995

The trend toward greater volatility in paper pricing is clearly illustrated in Figure 4, which shows market pricing and average total manufacturing costs for U.S. southern mills making uncoated freesheet photocopy paper and 42-pound linerboard. As the figure also shows, manufacturing costs gradually declined or remained stable, in real terms, from the early 1970s until 1994. The sharper decline in manufacturing costs for photocopy paper in the early 1970's was due in large part to the installation of more efficient systems for cutting rolls of paper into sheets. As these systems were installed, competition forced paper prices downward. The increase in manufacturing costs in the last two years is largely due to increased expenditures on fiber.

Paper Manufacturing and Forest Management

The need to keep mills operating at or near full capacity has important implications for forest management. Because the costs of mill shut-downs are high, fiber shortages must be avoided. Consequently, when wood supply is constrained, forest products companies may be willing to pay elevated prices for pulpwood on the open market and to increase harvests from their own lands. Moreover, in order to avoid shortages, pulp mills often maintain a several-weeks supply of pulpwood, either at the mill or at satellite storage facilities. Wood storage can be costly, as measures must be taken to prevent wood decay and maintain fiber quality.

The upside of the paper pricing cycle is in fact a key time for purchasers to express preferences for environmental improvements in the paper they buy.

The forest-products industry has significant capital investments in timberland. In fact, the industry owns nearly 25% of all U.S. lands classified as timberland. On average, roughly 25% of the forest-products industry's virgin fiber requirements are met by trees grown on industry land, although this varies among companies and even from mill to mill; some mills may not own any land, while others may satisfy almost all of their supply needs from company-owned lands. However, in most cases the majority of a mill's fiber requirements are met with pulpwood grown on non-industry lands, most of it purchased on the open market.

Timberlands owned by the forest-products industry are often managed using intensive, high-input forest management practices in order to maximize fiber yields. Such capital-intensive management regimes are a means for the forest-products industry to reduce pulpwood procurement costs, given that wood not produced on company land must be purchased elsewhere. Because most pulp mills must meet at least a portion of their fiber needs from company lands, management intensity and land are economic "substitutes:"[25] The company can choose to invest in increased production on its current land base or, alternatively, in increased land holdings.

What the Pricing Cycle Means for Purchasing Environmentally Preferable Paper

When paper prices are at their peak, suppliers have the power to set prices, and small buyers in particular are placed "on allocation." During the down part of the cycle, negotiating power shifts to buyers and paper producers will go to greater lengths to provide custom products and a level of service that can differentiate them from their competitors. Within established relationships between sellers and large buyers in particular, both parties can emphasize quality and service in any market conditions. Given this reality, it would appear that a period of high paper prices would not be the ideal time for paper buyers to ask their suppliers about environmentally motivated changes in their products. However, this concept is valid only if the situation is viewed from a short-term perspective.

The upside of the paper pricing cycle is in fact a key time for purchasers to express preferences for environmental improvements in the paper they buy, because they are doing so at a time when paper manufacturers are accumulating large amounts of available cash and are planning their next round of investments. The suggestion by the purchaser that environmental issues will be important over the long term is also very important. Most major equipment at a pulp and paper mill lasts for 15 to 30 years, and the economic penalty for retiring equipment before it reaches the end of its useful life is large. Furthermore, forest management decisions may have implications of substantially longer duration, as standard rotation ages can vary from 20 to as many as 60 years. Signaling the direction of long-term demand is therefore a major goal of the Paper Task Force's recommendations.

In addition to these factors, management among many companies that make or use paper is taking a longer view of supplier-customer relationships, with "strategic alliances" becoming more common. Within such relationships, paper users and papermakers can more confidently work together to develop innovations and new products that cut costs and produce greater stability and value for both parties through the market pricing cycle. This consideration is built into many of the implementation options that support the Task Force's recommendations.

Finally, a short-term pricing perspective also overlooks the important role that large paper purchasers in particular offer to paper manufacturers. While supply and demand forces set the market price for paper at any given time, individual customers may contribute differently to an individual paper mill's profit structure. For example, even at the same price for the paper, mills would prefer customers who buy in large quantities so that they can dedicate their machines for longer runs, which in turn lowers operating costs. Because paper manufacturers usually pay the freight for delivering their products, they prefer customers located near their mills over distant customers. Customers with growing demand for paper over time or those who buy steadily through recessions are also desirable. All of these factors can lead paper manufacturers to increase earnings not only by lowering their manufacturing costs, but by successfully competing for the most desired customers. Gaining a competitive advantage through environmental improvements can be part of this strategy.

The Global Perspective

Papermakers in the United States have been endowed with several factors that, combined with extensive and continuous reinvestment, have created an industry that is competitive on a worldwide scale. Major assets to U.S. producers include abundant forests, good growing seasons and ready access to the largest market in the world — U.S. consumers, who use roughly one-third of all the paper produced worldwide.

Pulp and paper products are commodities that are increasingly traded in international markets. According to the American Forest & Paper Association (AF&PA), the North American Free Trade Agreement and the Uruguay Round of the General Agreement of Trade Tariffs are expected to have positive impacts on the long-term export potential of the U.S. paper industry.

One forecast is that between 1990 and 2000, worldwide demand for paper will grow from 264 million short tons to 369 million short tons. Of this growth in demand, 49% is projected to occur in Asian markets.[25]

In dollar terms, the United States remains a net importer of paper products (largely Canadian market pulp and newsprint), while in tonnage terms the United States became a net exporter in 1989. This is because the major net export products are unfinished commodities like recovered paper and virgin market pulp and the major net import product is finished paper, which has a higher value; also overall exports have been growing faster than imports. Finished paper in the United States is still produced primarily for the domestic market. Over the longer term, international markets offer the U.S. industry a potential opportunity to expand output of finished paper beyond what the domestic market can absorb.

APPENDIX A: PAPER TASK FORCE MEMORANDUM OF AGREEMENT

(Generic version of the memorandum signed by all Task Force members)

Memorandum of Agreement

MEMORANDUM OF AGREEMENT BETWEEN
THE ENVIRONMENTAL DEFENSE FUND
AND _________________________
TO ESTABLISH A JOINT TASK FORCE ON
INCREASING DEMAND FOR ENVIRONMENTALLY
PREFERABLE PAPER PRODUCTS

The Environmental Defense Fund (EDF) and _____________ agree to establish a joint task force to investigate and prepare a report on opportunities for increasing institutional and consumer demand for environmentally preferable, competitively priced paper products. The primary focus of the task force will be on the potential to reduce the adverse impacts of pulp and paper production and to support large-scale recycling programs by increasing demand for recycled, unbleached, chlorine-free, and other environmentally preferable papers as determined by the task force's investigation. The final report of the task force will contain recommendations on purchasing environmentally preferable papers, including recommendations for specific uses of paper. These recommendations will reflect consideration of functionality, cost, availability and other factors relevant to business paper purchasing. Specific means of implementing the task force's recommendations will be determined individually by each of the organizations that make up the task force.

Composition of the Task Force:

The task force will be composed of EDF, _____________ and several other organizations that are major users of paper. These organizations are___________________________________
____.

Each organization will appoint at least two representatives to the task force.

Areas of Discussion:

The specific topics that may be addressed by the task force are set forth below. Additional topics may emerge as the work of the task force progresses.

- The technology and economics of pulp and paper production.
- The environmental impacts of paper production and use, and opportunities to reduce those impacts through alternative technologies.
- The types and quantities of paper products used by task force members, and the performance specifications of those products.
- Potential shifts toward the purchase and use of environmentally preferable papers that can be made by task force members and similar organizations.
- The benefits of purchasing environmentally preferable paper products, and the cost and availability of such products in the marketplace.
- Consumer preferences as they relate to environmentally preferable paper products.
- Task force members' source reduction and recycling programs and the relationship of their paper purchases to those programs.

Work of the Task Force:

The task force will require priority efforts and time commitments from its members over the course of a year to eighteen months. The task force will proceed according to a mutually agreed upon schedule, with meetings anticipated to be held every four to eight weeks. Task force members will convene for the purpose of detailed discussion and analysis of selected topics relevant to the subject matter areas set forth above. The task force may establish working groups to carry out specific investigations.

To the extent possible, task force members will rely on expertise within, or accessible to, their organizations, but they may draw upon additional outside expertise where necessary. The allocation of costs for retaining outside expertise or for substantial research and analytical activities will be made on a case-by-case basis by mutual agreement of the task force members.

EDF and ______________ agree to make available to one another information regarding their paper purchases and use, including information about paper types, quantities and suppliers; provided, however that all exchange of information that may raise any sensitive competitive or commercial issue is conducted pursuant to guidelines satisfactory to all participants. Where any information on paper use is considered proprietary in nature, it shall be provided subject to appropriate restrictions, mutually agreed upon in advance, to ensure that the confidentiality of the information is protected.

Each organization will pay independently all of its own expenses incurred as a result of its participation in the task force. Neither organization will accept support, monetary or in-kind, direct or indirect, from the other at any time. Each organization shall be free to use the research and information generated by the task force in its subsequent work unless restrictions, based on the disclosure of proprietary matters, are mutually agreed upon. Each organization may withdraw from the task force at any time. In the event that ______________ withdraws from the task force, we agree to manage the announcement of this action jointly. In no event will information regarding same be released without ______________'s consent.

Reports, Communications, and Publicity:

One goal of the task force will be to produce information regarding paper products and their use that has broad applicability to businesses and other institutions. Toward that end, the task force expects to produce a final report available to the general public. Dissemination to the public of specific results or agreements growing out of the task force will be by mutual consent. If task force members significantly disagree on data interpretation or particular conclusions drawn in any task force report, the report may contain separate statements written by each organization.

During the work of the task force, each organization will continue to carry out its business and advocacy activities with complete independence. During the course of these discussions and at the conclusion of the task force, each organization shall be free to state its own views, and pursue its own interests and goals, with respect to any matter or activity included in, or related to, the task force.

Each organization may communicate with its directors, shareholders, members, employees and, for non-profit organizations, potential funders, about the task force, subject to any restrictions on proprietary information. Each organization shall be permitted to submit information about the task force in response to any request for information from any governmental, judicial, administrative or regulatory body. With the exceptions just noted, neither EDF nor ______________ shall refer to the other's participation in or activities in connection with the task force, in any marketing, advertising, promotional material, point of sale material, or any other material directed at customers, the general public or the media unless expressly authorized by the other party.

Participating staff of each organization shall be available to provide up-to-date information on the activities of the task force. Written releases and media briefings conducted by the task force will make the public aware of significant developments or outcomes, if any, in the course of, and/or at the conclusion of, the task force.

______________________________	______________________________
Fred Krupp, Executive Director Environmental Defense Fund	Officer of Member Organization
______________________________	______________________________
Date	Date

APPENDIX B: LIST OF EXPERT PANEL TOPICS AND PANELISTS

The Paper Task Force Panels and Individual Panelists

Panel 1:

Functionality Requirements for Uncoated Business Papers and Effects of Incorporating Postconsumer Recycled Content

Panelists:

Carol Butler, International Paper
Gary Chapin, Xerox
Jobe Morrison, Cross Pointe
Kevin Nuernberger, Moore Business Forms
Steve Semenchuk, Superior Recycled Fiber

Panel 2:

Economics of Recycling as a Solid Waste Management Alternative

Panelists:

Jerry Ashby, Weyerhaeuser
Everett Bass, City of Houston Solid Waste Management Department
William Ferretti, New York State Department of Economic Development
Reid Lifset, Yale University
George Sanderlin, Browning Ferris Industries
Lynn Scarlett, Reason Foundation

Panel 3:

Environmental Comparison: Recycling vs. Other Solid Waste Management Methods

Panelists:

Marge Franklin, Franklin Associates
Howard Levenson, California Integrated Waste Management Board
Mary Sheil, New Jersey Department of Environmental Protection
Daniel J. Kemna, WMX Technologies
Joseph Visalli, New York State Energy Research & Development Authority

Panel 4:

Environmental Issues Associated with Forest Management

Panelists:

Gregory Aplet, The Wilderness Society
W.D. “Bill” Baughman, Westvaco
Derb Carter, Southern Environmental Law Center
Marshall Jacobson, International Paper
Neil Sampson, American Forests

Panel 5:

Environmental Comparison of Bleached Kraft Pulp Manufacturing Technologies

Panelists:

John Carey, Environment Canada
Gerard Closset, Champion International
Roland Lövblad, Södra Cell
Dale Phenicie, Georgia-Pacific
Peter Washburn, Natural Resources Council of Maine

Panel 6:

Functionality Issues For Corrugated Packaging and Folding Cartons Associated with Recycled Content, Source Reduction and Recyclability

Panelists:

David Etzel, Georgia-Pacific
Roger Hoffman, Hoffman Environmental Systems
Ralph Locke, Inland Container
John Schwann, Packaging Systems
Guyton Wilkinson, Stone Container

Panel 7:

Economic Comparison of Bleached Kraft Pulp Manufacturing Technologies

Panelists:

Jerry Crosby, Weyerhaeuser
Neil McCubbin, N. McCubbin Consultants
Samuel W. McKibbins, Champion International
Wells Nutt, Union Camp Technologies
Jean Renard, International Paper

Panel 8:

Functionality Requirements for Coated and Uncoated Publication Papers and Effects of Incorporating Postconsumer Recycled Content

Panelists:

Kathleen Gray, Green Seal
Jim Kolinski, Consolidated Papers
Tina Moylan, P.H. Glatfelter
Cliff Tebeau, R.R. Donnelley & Sons

Panel 9:

Economics of Manufacturing Virgin and Recycled-Content Papers

Panelists:

Don McBride, Rust Engineering
Richard Venditti, Union Camp
Arthur Verveka, Jaakko Pöyry Consulting
Frank Murray, Georgia-Pacific

Panel 10:

Environmental Comparison: Virgin and Recovered Fiber Manufacturing Technologies for Paper

Panelists:

Bill Clarke, Fletcher Challenge Canada
Jack Firkins, Boise Cascade
Norman Shroyer, for Union Camp
Allan Springer, University of Miami (Ohio)

ENDNOTES

[1] An example in the recycling area is a dialogue between state officials who are members of the Northeast Recycling Council (NERC) and major newspaper publishers. Michael Alexander, *Northeast Publishers' Commitments to Purchase Recycled Newsprint: A Status Report*, Brattleboro, VT: NERC, November, 1994.

[2] *Total energy* is that generated from combustion of all types of fuels, including fuels derived from wood by-products (bark, pulping liquors and paper), as well as fossil fuels and electricity purchased from utilities. *Purchased energy* represents only energy generated from combustion of purchased fuels (excluding combustion of wood-derived materials) and purchased electricity. Because a substantial amount of energy used in pulp and paper manufacturing (about 55%, industry-wide) is *self-generated* — i.e., derived from wood by-products rather than fossil fuel — the difference between total and purchased energy can be considerable, depending on the grade of paper, the processes used and the particular mill involved.

[3] The values reported here are for 1993, calculated using data from Franklin Associates, *Characterization of Municipal Solid Waste in the United States, 1994 Update*, prepared for U.S. Environmental Protection Agency, Municipal and Industrial Solid Waste Division, Washington, DC, Report No. EPA/530-S-94-042, November 1994.

[4] Except for some aspects of energy use, the environmental effects associated with obtaining virgin fiber from trees have not been considered here, due to their largely qualitative nature. Nonetheless, as discussed in detail in Chapter 4, intensive management of forests for fiber (and solid wood) production can have significant biological and ecological consequences (e.g., effects on biodiversity, wildlife habitat and natural ecosystems). Such consequences are an important difference between recycled fiber and virgin fiber-based systems.

[5] The Task Force has compared energy requirements and environmental releases from 100% recycled fiber-based and 100% virgin fiber-based systems that include the analogous activities in each system involved in the acquisition of fiber, production of paper and disposal of residuals. By examining entire systems rather than limiting our comparison only to the recycled vs. virgin manufacturing processes or the recovery vs. waste-management systems alone, we can better assess the full range of environmental consequences engendered by the choice between producing recycled-content paper and recovering and recycling used paper, as opposed to producing virgin paper, disposing of it and replacing it with new virgin paper. We recognize that paper often contains recycled content at levels lower than 100%, and that a steady influx of virgin fiber into the overall system is essential. Use of this basis for comparison, however, allows us to assess the relative energy use and environmental releases of each type of fiber arising from its acquisition, manufacture, use and post-use management by various means. Environmental attributes of paper containing intermediate levels of recycled content would fall between the estimates provided in this study for the 100% virgin and 100% recycled products.

[6] The Paper Task Force's "Guidelines on Data Collection" are available upon request.

[7] For example, Task Force members are not competitors, and generally purchase different kinds of paper for different uses. The Task Force's recommendations and their supporting rationale are published in this final report, which is available to the public. Decisions on the implementation of the recommendations are being made individually by each of the organizations that make up the Task Force; the Task Force is not a joint purchasing group. The paper industry is generally characterized by a low concentration of both buyers and sellers (i.e., there are large numbers of both). The combined paper purchasing of all of the Task Force members is far below the typical threshold for raising an anti-trust concern for joint purchasing groups. Finally, educational projects like the Paper Task Force are generally recognized as enhancing, not reducing, competition.

[8] The firms are Jaakko Pöyry Consulting, Inc. and Resource Information Systems, Inc.

[9] *Folio*, Special Sourcebook Issue, Magazine Publishers of America Annual Survey, 22(18), 1993.

[10] Joseph Hanlon, *Handbook of Package Engineering*, 2nd edition, Lancaster, PA: Technomic Publishing Co., 1992, p. 62.

[11] Coated unbleached kraft (CUK) paperboard is also known as solid unbleached sulfate (SUS) and coated natural kraft

(CNK) paperboard; the latter two names have been trademarked by Riverwood International Corp. and Mead Coated Board Corp., respectively.

[12] Marylin Bakker, editor-in-chief, *Encyclopedia of Packaging Technology*, New York: John Wiley & Sons, 1986, p. 147.

[13] James River Corp., written response to questions asked by Johnson & Johnson staff, Paper Task Force meeting, June 2, 1995.

[14] American Forest & Paper Association, *A Buyer's Guide to Recycled Paperboard*, Washington, DC: AF&PA, 1994, pp. 4-12; Joseph Hanlon, *Handbook of Package Engineering*, 2nd edition, Lancaster, PA: Technomic Publishing Co., 1992, Chapter 2.

[15] Between 1970 and 1991, annual net revenues increased on average by 8.3%, while annual capital expenditures increased on average by 9.3%. American Forest & Paper Association, *Paper, Paperboard & Wood Pulp, 1994 Statistics - Data Through 1993*, Washington, DC, 1994, pp. 62 and 66.

[16] American Forest & Paper Association, *Paper, Paperboard & Wood Pulp, 1994 Statistics - Data Through 1993*, Washington, DC, 1994, pp. 62 and 66.

[17] In 1970, total U.S. production of paper and paperboard was 53.4 million tons; production in the South was 25.6 million tons, or 48% of the total U.S. production (regions as defined by the U.S. Census). In 1992, total U.S. production was 89.5 million tons, and production in the South was 48.3 million tons (54%). American Forest & Paper Association, *Paper, Paperboard, and Wood Pulp; 1994 Statistics - Data Through 1993*, 1994, pp. 41 and 44.

[18] American Forest & Paper Association, 3*5th Annual Survey: Paper, Paperboard, Pulp Capacity and Fiber Consumption, 1993-1997*, 1994, p. 23.

[19] Based on estimates from waste-sorting studies that found that (in the absence of recycling programs) office workers discard approximately 0.7 to 1.6 pounds of white paper per person per day, depending on the type of business.

[20] In 1993, long-term debt as a proportion of total capital assets for the U.S. paper and allied products industry stood at 54%. In 1983, the same proportion was 33%. American Forest & Paper Association, *1994 Statistics: Paper, Paperboard and Wood Pulp*, Washington, DC: AF&PA, September 1994, p. 67.

[21] In 1980, there were 203,000 workers in pulp and paper mills and 65,000 workers in paperboard mills. *Statistical Abstract of the United States*, 1989, Table 657. In 1989, there were 194,300 workers in pulp and paper mills and 52,900 workers in paperboard mills. *1992 North American Pulp & Paper Factbook*, San Francisco: Miller-Freeman, 1991, p. 56, from U.S. Bureau of Labor Statistics data.

[22] Projections of total employment in the pulp and paper industry, 1994. Roughly 32% of total employment is in primary pulp, paper and paperboard mills; the remainder is in converting operations. U.S. Department of Commerce, *U.S. Industrial Outlook 1994*, January, 1995, p. 10-1.

[23] While large integrated pulp and paper mills can produce large quantities of paper at very low costs, they "sometimes have negative market consequences if too much capacity comes online, as in the 1990-91 period, which also coincided with the economic recession." *1992 North American Pulp and Paper Factbook*, San Francisco: Miller-Freeman, 1991, p. 186.

[24] John Chrysikopoulos, Uncoated Free Sheet Paper Markets, Goldman Sachs Investment Research, June 16, 1993, p. 2.

[25] Thomas J. Straka and James E. Hotvedt, "Timberland Ownership by Southern Companies." *Southern Pulp and Paper*, Vol. 12, (1984), pp. 17-19.

[26] Resource Information Systems, Inc. *RISI Long-Term Pulp & Paper Review*, RISI: Bedford, MA, July 1995, p. 227.

2 SOURCE REDUCTION

SOURCE REDUCTION

This chapter and the Paper Task Force recommendations on source reduction are intended to:

- Enhance the awareness of purchasers and users of paper that, in the great majority of cases, reducing paper use is a win-win situation——environmentally and economically——for businesses and other organizations.
- Present specific actions that have been identified by a number of sources (including Task Force member organizations) to reduce the use of paper associated with office settings, publications, direct mail applications and packaging.
- Provide information resources that can help businesses and institutions find opportunities to implement source reduction initiatives.

Recommendation: Systematically identify opportunities and take action to reduce the use of paper, and the amount of fiber used in specific paper products, both within your organization and in products related to your business, where consistent with functional considerations.

I. SOURCE REDUCTION: WHY SHOULD WE DO IT?

Paper use reduction, a form of source reduction, can achieve clear and measurable environmental and economic benefits. Using less paper can reduce environmental impacts across the entire lifecycle of paper — from fiber acquisition to manufacturing processes, distribution, use, storage and management of used paper after use. More specifically, this type of source reduction reduces the amount of paper that must be produced in the first place, thereby extending the fiber supply and avoiding the use of natural resources and the release of pollutants associated with acquiring raw materials and manufacturing. Decreasing the quantity of paper that is discarded also decreases the quantity of paper that must be stored, collected, transported, processed and managed.[1] In short, when consumers or businesses choose a source reduction strategy, they are choosing waste *prevention* over management or remediation.

Source reduction activities also can translate into immediate and long-term cost savings. Purchasers who reduce their use of paper save directly on purchasing costs, which are particularly significant in the current market, given the recent major price increases. Reducing the use of paper can reduce the costs associated with the storage of paper during use and the management (storage, collection, transportation and disposal) of used paper. Over the long term, reducing the amount of paper we use can help stabilize paper prices by extending a fiber supply that is in high demand. Source reduction can provide an aggregate economic benefit by, in effect, extending the supply of paper relative to demand.

In the great majority of cases, reducing paper use is a win-win situation — environmentally and economically — for consumers and businesses. For all of these reasons, the Task Force recommends that paper users systematically look for opportunities to reduce their use of paper as a key business and environmental strategy.

Source reduction should not be viewed as an impediment to the development of new products and/or technologies. In fact, incorporation of source reduction strategies at the outset in new product conceptualization and design offers opportunities to maximize the efficient use of paper in those products.

Numerous experts in government and business have examined source reduction and developed effective mechanisms for implementing it. Many examples from businesses and state and local governments demonstrate the cost savings that can be achieved through proactive efforts to reduce the amount of paper they use.[2] Because of the extensive work completed and ongoing in this area, the Task Force did not conduct major new research on source reduction as part of this project; rather, it focused on how organizations can more wisely purchase and manage the paper they do use. However, because source reduction is a primary means of reducing environmental impacts and costs associated with paper use, we provide in this chapter a brief discussion of its value, describe strategies and options, including some of those that have been implemented by Task Force members, and refer the reader to organizations, initiatives and resources published by others.

II.REDUCING PAPER USE IN YOUR ORGANIZATION: GETTING STARTED

Source reduction means a reduction in the amount (or toxicity) of material discarded (whether for disposal, treatment or recycling). In developing source reduction strategies, the priorities should be elimination, reuse and increased efficiency of use.[3] Using office paper as an example, organizations can eliminate some of their paper use through electronic filing and data storage systems. They can reuse paper already used on one side for drafts, memos or internal documents. They can increase their efficiency of use through two-sided printing and copying, printing documents single-spaced and using narrower margins or smaller typefaces. After assessing functional constraints, organizations can eliminate layers of packaging used for shipping or delivering a product, or reduce the amount of paper used in a product's packaging by lowering its basis weight.

In developing source reduction strategies, the priorities should be elimination, reuse and increased efficiency of use.

All paper users can implement source reduction. Whether an organization is large or small, has direct purchasing relationships with paper mills, purchases paper through vendors, or buys paper "off the shelf," it generally can identify opportunities to reduce paper use and reap immediate and tangible benefits through the greater efficiency achieved. Paper is ubiquitous, and we can't conduct our businesses without it. Source reduction offers organizations and individuals true opportunities to lessen the adverse effects of our paper use.

III. IMPLEMENTATION OPTIONS

In this section, we present specific actions that have been identified by a number of sources to reduce the use of paper and/or the amount of fiber in paper products associated with office settings, publications, direct mail applications and packaging. Not all of these actions are appropriate for every business, and they should be considered in the context of an overall source reduction program that organizations tailor to meet their individual needs. Important steps in developing such a program include:

- getting the support of management;
- conducting an assessment of your paper use;
- setting goals;
- developing a tracking system for your paper use and disposal;
- identifying potential paper uses that provide opportunities for source reduction; and
- monitoring progress toward goals.

The resources listed in Section IV can provide further guidance to carry out these steps.

Reduce Paper Use

Source Reduction Options in Office Settings

- Use double-sided copying whenever possible.
- Set photocopy machines, computer laser-jet printers and word processing software so that doublesided copying and printing is the default option; purchase office equipment and software that support double-sided imaging.
- Single-space documents.
- Change margins to avoid pages with little text.
- Review documents on the computer screen before printing.
- Collect and reuse paper already used on one side (for example, for drafts and internal memos).
- Use scrap paper for memo and telephone pads.
- Circulate and share copies of internal publications and documents.
- Post office announcements on bulletin boards.
- Faxing:Eliminate fax cover sheets or use alternatives such as re-positionable fax notes; program your fax to deliver "confirmation" sheets only for failed communications; update your "broadcast" fax lists; use plain paper, where appropriate, to reduce the number of copies made to replace thermal fax pages.
- Use reusable or two-way envelopes and mailing pouches (for example, for inter-office and inter-departmental communications).
- Improve office equipment to reduce paper usage (for example, buying copiers and laser printers that produce double-sided copying).
- Promote employees' awareness of waste reduction through education and incentives, and through waste audits and materials assessments to identify opportunities for source reduction.

Sources: EPA's "Environmental News," September 1995; EPA's WasteWi$e Update, May 1995; Colorado Hospitals' Environmental News, June 1995; Boeing News, August 1995; EDF's "Recycling World," 1994; INFORM Reports, summer 1995 & "Source Reduction Planning Checklist," 1994; MSW Management "Waste Prevention," 1993; National Office Paper Recycling Project's 1995 newsletters; North Carolina Recycling Association & North Carolina Office of Waste Reduction's "Source Reduction. It's a Bare Necessity" workshop manual, 1995; Resource Recycling "Does source reduction work?", July 1992; World Wildlife Fund & Conser vation Fund report "Getting at the Source: Strategies for Reducing Municipal Solid Waste," 1991; and actions implemented by Paper Task Force members.

Reducing Paper Use in Offices

Since the early 1970's, the discard of office paper has increased dramatically. While the population in the United States grew 16% from 1972 to 1987, printing and writing paper discards increased 73%, copier paper discards increased 150%, and other office paper discards increased 87%.[4] In the typical office, paper can represent between 50% and 70% of the total waste generated.[5]

The good news is that office paper waste is an excellent candidate for source reduction. Organizations have a high degree of control over its purchase, use and disposal, and there are many alternative source reduction options from which to choose. Below we cite examples gathered from numerous sources. Photocopying and laser printing consume almost half of the office paper used in the average office.[6] We suggest that organizations test alternatives that directly rely on office machines (for example, double-sided copying) to ensure appropriate performance on your particular office equipment. It may be necessary to modify equipment or change a brand of paper to implement these alternatives.

Publications and Direct Mail

For consumers, two of the most visible uses of paper appear as direct mail and publications such as magazines, annual reports and newsletters. There may be initial resistance to reducing the amount of paper used in successful commercial publications because these are important communication and advertising tools. However, more companies are finding ways to include their publications and their direct mail in source reduction strategies, and they are reaping economic and marketing benefits from doing so. (See Section III for initiatives implemented by Task Force members and Section IV for further references.) Listed on the next page are examples of options that organizations can consider.

Packaging

A recent poll by *Packaging* magazine showed that the top 100 largest industrial users of packaging materials spent $2.1 billion more to package their products in 1992 than in 1991.[7] Most of these companies indicate that annual expenditures on packaging will continue to increase throughout the 1990s.[8] Clearly there are economic incentives to eliminate or reduce packaging, and many businesses have taken steps to make this a reality.

Listed on the next page are potential opportunities for source reduction associated with the use of packaging materials. While primary packaging often is considered for source reduction, purchasers may overlook secondary and tertiary packaging. For example, corrugated packaging and linerboard offer a wide range of source reduction opportunities. (See Section III for initiatives implemented by Task Force members.) Companies will need to work with their suppliers, customers and employees to assess functional constraints and identify source reduction opportunities for the packaging materials specific to their products.

Electronic Communications

The presence of electronic reprographics and communications in the workplace and home is affecting the use of paper in the United States. This brief report on these trends is by no means comprehensive,[9] but may suggest to paper users ways in which electronic systems can increase, shift or decrease paper use.

Increases in Paper Use. The increased availability of photocopy machines, computer printers and fax machines that provide high-quality reproduction at a low cost per page clearly has led to an increase in per-capita use of "office paper" in the past two decades. As personal computers, fax machines and printers have become less expensive, they now are being used in more and more households. It is estimated that one-third of all U.S. households had personal computers in 1994, and there will be as many as 200 million computer users by the end of the decade.[10]

Shifts in Paper Use. One change in office paper use over the last decade has been an increase in the printing of "on demand" or "electronic" business forms stored on computers, which are substituting for continuous paper forms that are preprinted in quantity and stored prior to use. Due to this substitution, one projection is that annual growth in forms bond paper will be only 0.1% between 1994 and 2000, compared to 3.9% for cut-size (photocopy) uncoated freesheet business papers.[11]

Decreases in Paper Use. Many electronic system areas provide the potential for reducing the use of paper, including: (1) the use of electronic mail in place of paper memos and faxes; (2) the development of word processing and editing programs that allow for less use of paper in writing reports and writing, editing and producing books and magazines;[12] (3) the storage of techı books, manuals, directories and encyclopedias on CI ROM[13] or computer disks in place of conventional books;[14] (4) electronic publishing[15] of newspapers, books and catalogs, which encompasses CD-ROM magazines, online information services and "interactive shopping networks"; and (5) electronic business transactions, especially in banking.[16]

The conventional wisdom among paper industry forecasters is that "for every ton of paper displaced by computers, there is more than one ton of new demand generated."[17] This certainly has been true in the past, and any future reduction in paper use due to electronic communication may lead to a decrease in the growth in demand rather than aı absolute reduction of per-capita demand.

Given the rapid evolution of technology in this area, for ing is an uncertain proposition. Like double-sided photoc

Reduce Paper Use

Source Reduction Options for Publications and Direct Mail

- Reduce the basis weight for magazines, newsletters and other commercial publications,where functionally appropriate for the end use.
- Donate old magazines to charitable organizations.
- Reduce the frequency of catalog mailings.
- Reduce direct mail in the waste stream by updating mailing lists frequently and targeting specific audiences as precisely as possible to reduce the amount of direct mail sent.
- Individual businesses can reduce the amount of direct mail received, where appropriate, by getting on preference lists for different direct mail advertisers. See Section IV for information on the Direct Marketing Association.

Sources: INFORM Reports, summer 1995 & "Source Reduction Planning Checklist," 1994; World Wildlife Fund & Conservation Fund report "Getting at the Source:Strategies for Reducing Municipal Solid Waste," 1991; and actions implemented by Paper Task Force members.

aser-jet printing, the ultimate impact of electronic commu-ication on paper use may be largely determined not only by the technology itself, but by how it is used. As businesses expand their computer networks, for example, they should consider how equipment and software being put in place can cut paper use. This may be as simple (or complex) as convincing users of office E-mail to save important messages on their computer hard drives, rather than reflexively printing them out.

Reduce Paper Use

Source Reduction Options for Packaging Materials

- Eliminate packaging. The need for any packaging can be evaluated in the early stages of development and introduction to the market.
- Minimize packaging through package redesign. Purchasers should work with suppliers to develop alternative packaging designs that minimize the use of materials. Examples are lightweighting, downsizing packaging and/or optimizing volume contained in packages.
- Identify opportunities to reduce waste in all areas of packaging — primary, secondary, tertiary and transport packaging.
- Use returnable/reusable shipping boxes.

Sources: EPA's WasteWi$e Update, May 1995; INFORM Reports, summer 1995 & "Source Reduction Planning Checklist", 1994; MSW Management "Waste Prevention," 1993; North Carolina Recycling Association & North Carolina Office of Waste Reduction's "Source Reduction. It's a Bare Necessity" workshop manual, 1995; Resource Recycling "Does Source Reduction Work?", July 1992;World Wildlife Fund & Conservation Fund report "Getting at the Source:Strategies for Reducing Municipal Solid Waste," 1991; and actions implemented by Paper Task Force members. .

Implementation Examples from the Paper Task Force

For ideas on how to develop a source reduction program and implementation options that work for your organiza-on, see the resources listed in Section IV. Below are brief riptions of some of the efforts by Task Force members to the use of paper in our businesses.

1. Source Reduction in Office Settings

Duke and The Prudential have increased the use of electronic communications in their operations. Duke University is designing an electronic procurement system that will replace a dozen paper systems. In the near future, people will order supplies from their desktop computer by pulling up an electronic catalog. They can select the items they need and transmit the order to the vendor electronically. Funds will be transferred electronically from Duke's bank to the banks of major suppliers. This will virtually eliminate paper purchase orders, invoices and checks.

Other business forms such as travel and expense reports will be processed electronically at the user's desktop computer. Electronic mail and the Home Page have replaced much of the paper correspondence and documents at Duke University.

At The Prudential, electronic communications and other computer-related technologies have continued to provide more efficient uses of the company's paper resources. Company-wide electronic mail, hundreds of interactive online forms, and the electronic storage of forms with print on demand capabilities have all contributed toward reducing the demand for paper within The Prudential.

Just a few of the available electronic forms and online services at The Prudential are: company-wide electronic bulletin boards, online Enterprise policy statements and job postings, electronic travel and entertainment expense vouchers, online registration for employee training and development classes, and online employee surveys.

2. Source Reduction in Direct Mail and Publications

Time Inc. has instituted several programs to reduce its use of paper and improve efficiency. Time Inc. is actively engaged in a major initiative to change the way its magazines are distributed to newsstands by selectively binding magazines for each retail outlet. This change will have the impact of substantially reducing the number of copies placed on newsstands while maintaining, or even enhancing, the number of copies sold. Time Inc. has encouraged its printers to purchase more efficient presses and to employ various production methods and contractual stipulations to reduce paper spoilage. Over time, all of these changes will help reduce paper consumption by $20-30 million annually.

The use of paper forms in paper purchasing has been reduced by using Electronic Data Interchange (EDI) for all purchase orders, purchase order acknowledgments, manifests and receipts. In the future EDI will be used for invoicing, and other technologies will be employed to reduce paper waste.

Other initiatives include the potential of printing magazines in a waterless environment (without fountain solutions) to eliminate waste, reduce paper spoilage and further improve efficiency.

As part of its source reduction goals, the Environmental Defense Fund (EDF) first assessed the volume and types of paper that the organization buys. EDF then targeted for source reduction its category of largest paper use by volume, which is direct mail. EDF is experimenting with different source reduction strategies. For example, EDF wrote a joint fundraising letter with another environmental organization in which the two groups described how the joint mailing would reduce environmental impacts and save money; this letter was more successful for EDF than previous mailings to new prospects. For a selected pool of donors, EDF has reduced its annual number of mailings by half. All direct mailings are printed on both sides of the sheet. EDF also is experimenting with a two-way envelope; such envelopes use less paper, and their use in mailings may cost less than the combination of a regular carrier envelope and a reply envelope.

Over the last year, EDF made a major reduction in its newsletter paper use by changing twice to lighter stock, dropping the basis weight from 61 pounds to 54 pounds to its current 47 pounds. The newsletter contains the same number of pages as before but has achieved an approximate 25% reduction in paper used.

EDF gradually is replacing old laser printers with printers that have duplex capability and is seeking to shift to electronic communication where possible. EDF has used computer networks and E-mail within and among all of its offices nationwide since 1984. Recent investments in notebook computers for staff reduce the need to print out and carry documents or receive faxes when away from the office. The EDF newsletter and a substantial body of EDF information should be available in paperless form as EDF launches its World Wide Web site in late 1995, and members are encouraged to use this network when they are able to do so. The work of the Paper Task Force and related updates will also be posted on the World Wide Web at www.edf.org.

3. Source Reduction in Packaging Materials

Initiatives by Task Force members McDonald's Corporation and Johnson & Johnson demonstrate that waste reduction efforts at large companies can yield big savings. In 1994, McDonald's saved approximately $5 million by reducing packaging in the following ways: reducing the raised designs on napkins; redesigning the company's shake and sundae shipment boxes; converting hash brown containers to paper bags; and redesigning french fry cartons to reduce the weight of paperboard packaging.

McDonald's Corporation has been able to reduce its corrugated usage over the years by (1) continually reevaluating the traditional ways boxes are designed and used, and (2) looking for opportunities in secondary and tertiary packaging as well as primary packaging. For instance, by challenging the theory that a box always has to be completely closed, McDonald's trimmed one inch off the top flaps of the corrugated box in which its milk shake mix is shipped, leaving a two-inch gap at the top of the box. This reduced the corrugated board by 4%, or 220 tons per year, and saved 2% of packaging costs for this product.

A combination of strategies can be implemented to achieve source reduction—strategies such as package redesign, lightweighting, downsizing and elimination of materials.

McDonald's has reduced the amount of corrugated used in its case packs by optimizing the space and volume required for these shipping containers. A reassessment of the usage of 32 oz. cold cups and lids at McDonald's restaurants found that increasing the case pack of cups and lids from 500 to 800 better served the needs of the restaurant while resulting in a source reduction of 70 tons of containerboard per year.

McDonald's also found an opportunity to reduce packaging through primary product redesign. Working with one of its suppliers, McDonald's reduced the background emboss of its napkins. This led to a source reduction in both primary and secondary packaging. The number of napkins per packaging sleeve increased, resulting in fewer sleeves per case, a 25% source reduction, or a reduction in annual material usage of 12 tons. The size of the box decreased, while still packing the same number of napkins in a case, resulting in a 23% source reduction, or 18 tons of containerboard per year. Previously another napkin supplier had come to McDonald's with a proposal to reduce the amount of material in the napkin by 21%, by trimming one edge and folding the napkin in a way that did not change its folded size.

Johnson & Johnson began developing its waste reduction program in 1988 with a comprehensive review of its product packaging in a search for ways to cut back on the amount of materials it purchased, as well as the amount of waste associated with the manufacture and use of these products. As a result, the company has implemented a series of action steps that have reduced its packaging by 2,750 tons a year, including a reduction of its paper use by 1,600 tons per year. In the first two and a half years of the program, the company saved an estimated $2.8 million in total packaging material costs.

Specific examples from Johnson & Johnson demonstrate how a combination of strategies can be implemented to achieve source reduction — strategies such as package redesign, lightweighting, downsizing and elimination of materials. In the packaging of one gauze product, the basis weight of the product's packaging was lowered from 30-pound to 28-pound paper, resulting in a reduction in waste of 230,000 pounds of paper and cost savings of $450,000 annually. The company switched the well-known Band-Aid™ Brand Adhesive Bandages from tin to paperboard cartons which reduced waste by 1.8 million pounds and saved $3.8 million through source reduction and standardization.

The Ortho McNeil Pharmaceutical Division of Johnson & Johnson has achieved significant reductions in paper use and costs by using all of the strategies identified above. In one product (FactPlus), a partition used in the package was eliminated, the overall size of the carton was reduced, and the brochure insert was downsized. Package redesigns on three other Ortho McNeil products successfully downsized shipping containers, folding cartons, and reduced paper use required for insert brochures. In total, these four products have reduced annual folding carton usage by 132,750 pounds, annual corrugated usage by 523,000 pounds and produced annual cost savings of approximately $990,000.

IV. INFORMATION RESOURCES

The following resources can provide information to organizations on source reduction.

- Environmental Protection Agency (EPA). EPA has numerous initiatives and publications that directly address source reduction for paper and packaging use. WasteWi$e is a voluntary program initiated by the Environmental Protection Agency to stimulate American businesses in waste prevention, recycling and the purchase of recycled products. One WasteWise project plans to focus specifically on paper use. The goal of this project is to identify high-impact paper conservation practices, document in detail how these practices were successfully implemented by several companies and disseminate this information to other companies. Contact: WasteWi$e (5306), U.S. Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460, telephone: 800-EPA-WISE.
- INFORM, a nonprofit environmental research organization, has written numerous publications and manuals that discuss how to create effective source reduction programs. Some of the publications also describe specific activities that are being carried out across the United States. Contact: INFORM, 120 Wall St., New York, NY 10005-4001, telephone: (212) 361-2400.
- CONEG, the Coalition of Northeast Governors, brings together representatives of nine northeastern states to explore problems, exchange information and solutions, and undertake cooperative actions. Reduction of packaging waste has been the focus of a major CONEG initiative. CONEG has published a preferred packaging manual that could be useful to purchasers and their offices. Contact: CONEG, 400 N. Capitol Street, Washington, DC 20001, telephone: (202) 624-8450.
- The National Recycling Coalition (NRC) is conducting a joint project with EPA that focuses on source reduction. The project is called the Source Reduction Forum. Contact: NRC, 1727 King Street, Ste 105, Alexandria, VA, 22314-2720, telephone: (703) 683-9025.

- A 1991 report, "Getting at the Source: Strategies for Reducing Municipal Solid Waste," examines how the design and use of products, including paper, can be altered to reduce the amount and toxicity of municipal solid waste. The report was written by a steering committee of experts from a wide range of perspectives and was published by World Wildlife Fund and The Conservation Foundation. Contact: World Wildlife Fund, 1250 24th Street, NW, Washington, DC 20037, telephone: (202) 293-4800.
- *Reusable Transport Packaging Directory*. This directory was published in 1994 by the Minnesota Office of Waste Management to help companies locate manufacturers of reusable packaging materials. Contact: the Minnesota Office of Waste Management or call 1-800-EPA-WISE for a copy.
- Government technical assistance programs can help businesses and institutions conduct waste audits and materials assessments, recognize opportunities for reducing waste and implement source reduction programs.[18] Some state and local governments give grants to stimulate businesses and institutions to develop innovative strategies to reduce waste. Some state and local governments give awards to recognize businesses, institutions or individuals for significant achievements in source reduction or product design. Purchasers can learn about specific government programs through appropriate local, state or federal agencies.
- Johnson & Johnson has produced a software program (Pack-Track) available upon request that provides guidance on identifying, tracking and monitoring source reduction for packaging. Contact: Johnson & Johnson, 1 Johnson & Johnson Plaza, New Brunswick, NJ 08933, telephone: (908) 524-6331.
- The National Office Paper Recycling Project, a project of the U.S. Conference of Mayors, works with American businesses to maximize recycling and minimize waste. The focus is on paper products, purchase and disposal. Businesses, institutions and governments can join the program. NOPRP also is starting a new project focused on source reduction. Contact: NOPRP, U.S. Conference of Mayors, 1620 Eye Street, #600, Washington, DC 20006, telephone: (202) 223-3088.
- Several publications may contain articles on source reduction. Examples of such publications include: *Waste Age*, *Resource Recycling*, *MSW Management* and *BioCycle*.
- Direct Marketing Association (DMA) has a "mail preference system" to block the sale or trading of your name and address among different mail advertisers. Contact: DMA, 1120 Avenue of the Americas, New York, NY, 10036-6700, telephone: (212) 768-7277.

ENDNOTES

[1] North Carolina Recycling Association & North Carolina Office of Waste Reduction, *Source Reduction. It's a Bare Necessity* workshop manual, 1995.

[2] Several of the sources cited in Section IV have published materials that contain examples of source reduction initiatives implemented by specific businesses. In particular, contact EPA's WasteWi$e program, CONEG and INFORM. State governments often have specific programs that recognize successful source reduction activities by businesses.

[3] North Carolina Recycling Association & North Carolina Office of Waste Reduction, *Source Reduction. It's a Bare Necessity* workshop manual, 1995.

[4] North Carolina Recycling Association & North Carolina Office of Waste Reduction, *Source Reduction. It's a Bare Necessity* workshop manual, 1995, p. 46.

[5] EPA's "Environmental News," September 1995.

[6] EPA's "Environmental News," September 1995.

[7] North Carolina Recycling Association & North Carolina Office of Waste Reduction, *Source Reduction. It's a Bare Necessity* workshop manual, 1995, p. 40.

[8] North Carolina Recycling Association & North Carolina Office of Waste Reduction, *Source Reduction. It's a Bare Necessity* workshop manual, 1995, p. 40.

[9] Electronic systems entail environmental impacts such as energy use and materials consumption in manufacturing. The Paper Task Force has not analyzed these impacts in detail. It should be noted that the environmental impacts from increases in paper use versus electronic communication may be different at the margins. The environmental impact of using an additional ton of paper is generally the same as using the prior ton; the same amount of wood fiber, chemicals, etc. are required in manufacturing. Assuming that a computer network is already in place, the increased use of electronic mail, for example, would cause a declining environmental impact per communication, since certain basic energy and materials use factors would be spread over more individual transactions.

[10] Charles Platt, "Beats Skinning Hogs," *Wired* 3.05, May 1995, p. 164; Peter Lewis, *The New York Times*, Tuesday, January 3, 1995, Section C, p .15.

[11] Resource Information Systems, Inc., *RISI Long-Term Pulp and Paper Review*, RISI: Bedford, MA, July 1995, p. 53.

[12] Almost every book published in the U.S. during the last 15 years has been produced digitally, making the transition to an all-digital publishing process easier for paper publishers. Traditionally, editing documents required paper, because word processor programs lacked editing symbols. New hardware and software now have this capability and, therefore, can eliminate the need for paper at this stage. An example is PenEdit, a keyboard and pen-driven portable computer allowing the use of editing symbols. The machine is portable, the process is paperless, revisions can be transmitted digitally and the editing process itself can be more efficient. Several publishing companies, including Viking and Doubleday, use PenEdit. Digitizing text, pictures, video and sound is becoming commonplace and very affordable. *Wired* 3.05, May 1995; Paul Hilts, "I Sing the Editor Electric," *Publishers Weekly*, January 3, 1994, p. 43.

[13] CD-ROM disks are the medium most commonly used for the storage of large amounts of information. A CD-ROM can store the equivalent of 250,000 pages of text. "Just How Big Is the Interactive Market?", *Forbes ASAP*, April 10, 1995, p. 69.

[14] CD-ROM is in wide use today, with over 17 million computers capable of running CD-ROM software. Stephen C. Miller, *The New York Times*, Monday September 5, 1994, p. 35. Almost all computers sold today include a CD-ROM drive. In 1993, $200 million worth of CD-ROM programs were purchased. *Multimedia Publishing: Taking Care of Business*, supplement to Volume 241, *Publisher's Weekly*, #42, October 17, 1994. Over a dozen companies publish multimedia magazines solely on CD, while many more publish magazines in both paper and disk formats. Stephen C. Miller, *The New York Times*, September 5, 1994, Sec. 1, p. 35. 50,000 titles were published for bookstores in 1994, and CD-ROM sales were 3% of trade-book sales. The 1989 Oxford English Dictionary sold four times as many copies on CD-ROM as on paper. D.T. Max, "The End of the Book?," *0*, September, 1994, p. 61-71.

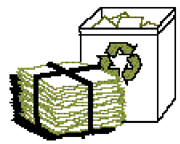
[15] Electronic publishing is any publishing process where the published material is in a digital format when sold to the consumer. The material is either sold as a packaged product or transmitted directly to the consumer. By this definition, electronic publishing may be achieved either by an all-digital (and almost paperless) process or by converting paper text and accompanying graphics to a digital format at a step prior to the dissemination of the material.

[16] *Publishers Weekly* believes 229 U.S. publishers currently display their wares on the World Wide Web. Tony Seideman, "Working on the World Wide Web: Publishers Discover the Internet in Business," *Publishers Weekly*, May 25, 1995, pp. 54-56. Over 75 newspapers have electronic editions on line. Web shopping malls exist, consolidating shopping and advertising in one location consumers can visit. About 20 million consumers and sales of $4.8 billion are projected for 1998. "Just How Big is the Interactive Market?", *Forbes* ASAP, April 10, 1995, p. 69.

[17] Resource Information Systems, Inc., *RISI Long-Term Pulp and Paper Review*, RISI: Bedford, MA, July 1995, p. 52.

[18] "Source Reduction Planning Checklist," an INFORM publication, 1992.

3 RECYCLING AND BUYING RECYCLED PAPER



RECYCLING AND BUYING RECYCLED PAPER

The Paper Task Force has conducted a comprehensive analysis of the environmental, economic and paper performance aspects of paper recycling. This research shows:

- Over the full lifecycle of paper products, recycling provides extensive, clear and measurable environmental advantages compared to virgin fiber systems.
- For most grades of paper, products with recycled content that meet users' functional needs and perform comparably to virgin paper are widely available.
- Recycling offers a powerful but not widely recognized means for paper purchasers, acting in the aggregate, to increase supply and reduce prices for new paper products over the medium term by changing the dynamics of the market.

I. INTRODUCTION

This chapter has six major parts:

- This *introduction* presents basic background information on paper recycling in the United States
- The *recommendations for purchasers and users of paper,* followed by a short rationale and summary of the Task Force's key findings
- *Implementation options*, which provide purchasers with a wide range of tools, techniques and suggestions for putting the recommendations into action
- *General conclusions* of the Task Force on recycling, in the areas of environmental issues, paper performance and economics
- *Findings for specific grades of paper,* also covering environmental issues, paper performance and economics
- *Answers to frequently asked questions* about buying and using recycled paper

The Use, Recycling and Disposal of Paper in the United States

Paper makes up one-third of municipal solid waste nationwide, and can make up 90% of the material generated in offices.[1] Paper is an excellent material to collect for recycling. It is abundant, easy for people to identify and sort, can be compacted in collection trucks, and has large national and overseas markets.

The process of paper recycling begins with the manufacturing of new paper. The United States produces about 30% of all the paper made worldwide.[2] Our country is also a net importer of paper, both in the form of large rolls, and as finished products, such as corrugated boxes used to package imported goods. Approximately 9% of U.S. paper production becomes manufacturing scrap when it is converted into finished products like envelopes, boxes, cups, magazines, etc. Almost all of this "pre-consumer" paper trim is recycled.[3] Some paper products become unavailable for recycling when they are put into long-term storage or sent into sewage and septic systems.

Taking all these factors into account, in 1993, U.S. households and businesses used 77.8 million tons of finished "postconsumer" paper products. Of this amount, 34% was collected for recycling and 66% ended up in landfills or incinerators.[4] Including preconsumer paper scrap in the picture, in 1993, about 38% of the total paper available in the United States was collected for recycling. This rate surpassed 40% in 1995, compared to 27% a decade earlier.[5] The paper industry has established a goal of a 50% paper recovery rate by the year 2000.[6]

Of the paper collected for recycling in the United States in 1993, 80% was used by domestic paper mills, 17% was exported and 3% was used in products like cellulose insulation and animal bedding.[7] The tonnages of paper produced, used, recycled and disposed in the United States in 1993 are shown in Table 1.

The environmental comparison and economic analysis in this chapter covers the lifecycle of recycled and virgin paper. The Task Force's analysis approaches recycling as a complete system, as depicted in Figure 1. All parts of the recycling sequence — collection, intermediate processing, manufacturing and the use of recycled products — must work together for the system to function effectively. Not all paper products can be recycled, due to contamination and practical and economic limits on collection; some paper will always become solid waste. An input of virgin fiber into the system is necessary to sustain a balance with used paper that is discarded or exported for recycling, and to maintain the physical properties of paper products.

II. RECOMMENDATIONS

Based on the definitive environmental and economic advantages of paper recycling, the Paper Task Force makes the following recommendations.

Recommendation 1. Paper users should actively expand and optimize paper recycling collection programs. Paper users also should promote recycling activities and assist efforts to develop the paper recycling infrastructure in the following areas, as appropriate to the capabilities of your organization:

- *within the premises of your business*
- *for the products distributed by your company or your industry*
- *in the communities in which your business operates*
- *among the broader business community and general public.*

Recommendation 2. Paper purchasers should maximize their overall use of paper with postconsumer recycled content, consistent with functional and economic considerations.

Table 1

Paper in the United States, 1993

STATISTICAL CATEGORY	MILLIONS OF SHORT TONS
U.S. paper production	86.7
Net U.S. imports of paper as rolls and products (imports minus exports)	4.8
"New Supply" (U.S. production plus net imports)	91.5
Postconsumer paper products recycled or disposed	77.8
Preconsumer paper collected for recycling	8.5
Postconsumer paper collected for recycling	26.4
Total paper collected for recycling	34.9
Utilization of recovered paper by U.S. paper mills	28.0
U.S. manufacturers' use of recovered paper in other products	1.2
Exports of recovered paper	5.9

Notes:

Preconsumer paper collection for recycling estimated as total paper collection (AF&PA) - postconsumer paper collection (Franklin).
"Other products" include molded pulp packaging (e.g., egg cartons), cellulose insulation, animal bedding, shredded packaging, etc.
Sources: American Forest & Paper Association, 1995; Franklin Associates, Ltd., 1991; Franklin Associates, Ltd., 1994 (see endnotes 3-5).

Recommendation 3. Paper users and purchasers should design and purchase paper products that can be recycled readily after their use.

Implementation options to help paper purchasers and users put these recommendations into practice are provided in the third section of this chapter.

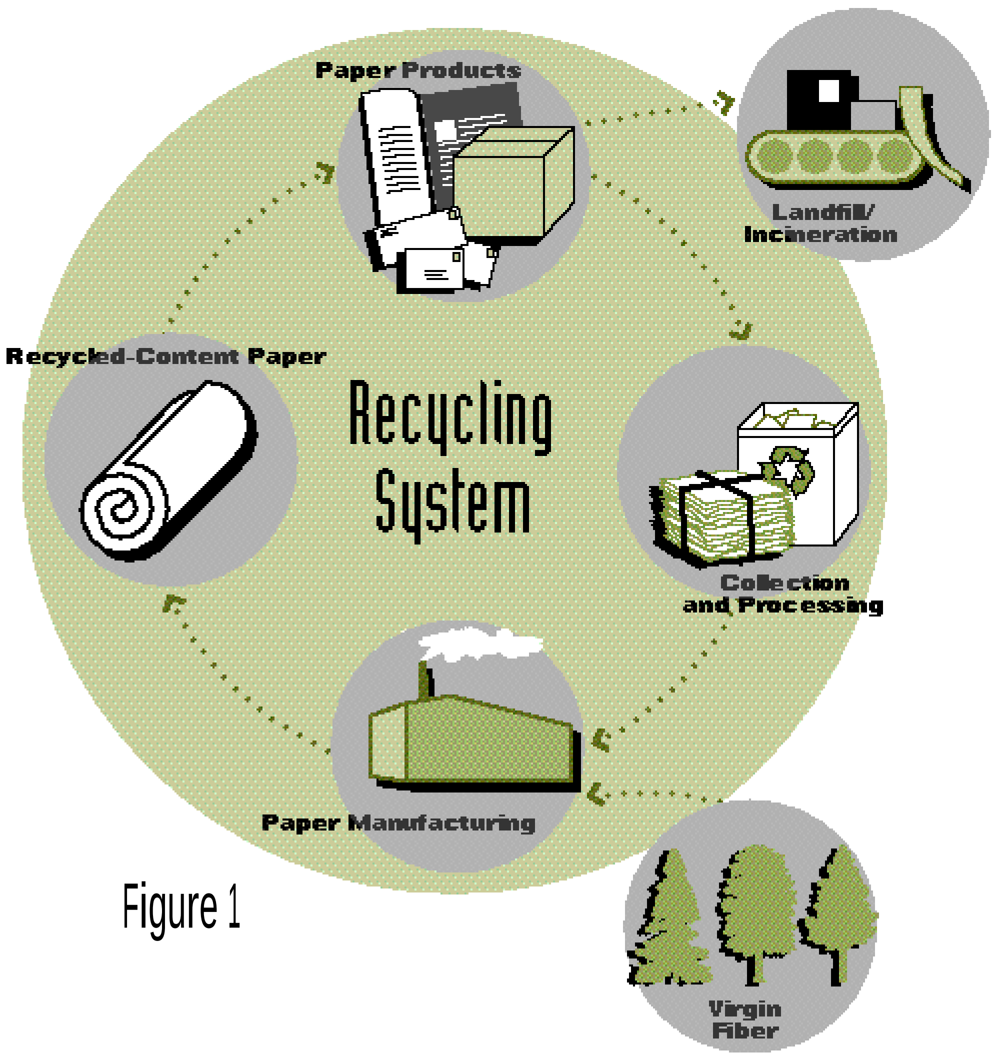


Figure 1

Rationale for the Recommendations and Summary of Task Force Findings

The Task Force's recommendations call for action on both the supply and demand sides of the recycling equation. Recommendation 1, collecting used paper for recycling, provides a raw material for making new paper and reduces the disposal of paper products in solid waste landfills and incinerators. Buying recycled paper, the subject of Recommendation 2, is essential to "close the loop" in the recycling system and encourages manufacturers to invest in recycling technology and research and development. Recommendation 3, purchasing paper products that are designed to be easily recycled, makes the whole system work more efficiently.

1. Environmental comparison

Paper recycling offers abundant environmental advantages compared to virgin paper systems. The Paper Task Force has compared two complete systems of virgin and recycled paper use. These systems are (1) the production of virgin paper and its disposal in landfills or incinerators, and (2) the operation of paper-recycling collection programs and the manufacturing of paper with recycled content. This comparison was made for each of the grades of paper examined in this project.

The Task Force's extensive research shows that paper recycling significantly reduces releases of numerous air and water pollutants to the environment, reduces solid waste, and conserves energy and forest resources. These environmental advantages generally are found across all comparable grades of recycled and virgin paper studied by the Task Force.

2. Paper performance

For all of the paper grades that the Task Force studied, recycled paper is available that meets users' performance needs and functions comparably to virgin papers in office equipment, printing presses and packaging machinery. Making recycled-content paper does require adjustments in the manufacturing process to compensate for the differences between recycled and virgin fibers. Some types of paper use a blend of virgin and recycled fibers to obtain desired properties. Overall, the changes in mill technology and operations required to use recycled fibers are within papermakers' technical capabilities. Most paper manufacturers have less experience using recycled fiber in making printing and writing paper than they do using paperboard, tissue, newsprint and other grades that traditionally have contained some recycled content.

3. Economics

Informed, strategic action on paper recycling can also produce considerable economic benefits for paper buyers and users. Not all of these benefits will be immediately available to all paper users, especially given recent fluctuations in markets for both new paper products and recovered (used) paper. However, strong support of paper recycling should be part of all major paper users' economic strategy for favorably changing the dynamics of the market for new paper products. The Task Force investigated three major aspects of the economic costs and benefits of paper recycling, summarized below.

a) Recycling and solid waste management costs

The business of paper recycling is in the midst of a major period of change, which began around 1985 and will close by the late 1990's. A key indicator for this transition is the market price for recovered paper. From 1990 to early 1994, U.S. prices for recovered paper grades such as old newspapers and corrugated boxes were at historical lows. This was due to an excess of supply compared to demand caused by the advent of thousands of municipal and private-sector recycling programs and the 1991-1992 recession. In this same period, U.S. papermakers began making large investments in recycling-based paper manufacturing capacity, projected to total more than $10 billion in the 1990s.[8]

This new recycling capacity plus growing demand for paper in general has dramatically reversed the situation in recovered paper markets, as shown in Table 2. Experts project that recovered paper prices will be volatile through the rest of the decade, and on average will remain high compared to 1990-1993 but generally not as severe as in mid-1995.[9] *For paper users and recycling collectors, higher prices for recovered paper present an income opportunity and an alternative to paying for solid waste disposal.* Greater demand for paper by U.S. mills is also increasing the competition and quality of service offered by recycling collection companies.

b) Comparative costs of manufacturing recycled and vi paper

The economics of manufacturing virgin and recycled paper products vary among different regions, paper grades and mills. Recycling can provide economic returns that are competitive or superior to manufacturing using virgin fiber under certain conditions. Recovered fiber processing systems generally are installed at a smaller

Table 2

Recent U.S. Prices for Recovered Paper
(Prices paid by mills, dollars per short ton, f.o.b. seller's dock)

Recovered Paper Grade	Nov. 1993 (end of mid-1991 to late-1993 low period)	June,1995 (approx.peak-highest price in real terms since 1974)	October 1995 (downward adjustment in a volatile market)	Projected price range, 1996-1998, in 1995 dollars
Mixed paper (1)	$0-10	$85-140	$15-35	
Newspapers (6)	0-20	145-180	55-95	80-145
Magazines (10)	10-25	100-175	75-130	
Corrugated containers (11)	10-25	160-190	30-65	50-155
Sorted office paper (37)	N.A.	250-290	150-220	190-300
Sorted white ledger (40)	105-120	340-400	200-280	
Laser computer printout (42)	140-180	380-430	250-290	
Laser-free computer printout (42)	175-230	450-500	300-365	

Note:
Numbers following each grade are classifications from the *Scrap Specifications Circular 1994; Guidelines for Paper Stock: PS-94*, published by the Paper Stock Industries Chapter of the Institute of Scrap Recycling Industries. Ranges reflect variations in transaction prices both within and among different U.S. regions.

Source: *Paper Recycler* newsletter, Miller Freeman, Inc.; projections from Jaakko Pöyry Consulting Inc., 1995

economic scale and a lower capital cost per ton of production compared to huge new virgin pulp mills.[10] They can also be designed and built more rapidly and obtain environmental permits more readily than virgin pulp mills. For this reason, fiber recycling facilities tend to be well-suited for supporting incremental expansions in pap production, which are a common means of growth in the in try.[11] The comparative costs of manufacturing virgin and re paper are also sensitive to recovered paper market prices.

Recovered-fiber processing technology has long been available for mills that make linerboard, corrugating medium, 100% recycled paperboard, newsprint, certain types of tissue and toweling, and some specialty uncoated printing and writing papers such as text and cover paper. *When the cost of recovered paper is within its historical range, these types of paper are generally less costly to produce with recycled content than comparable grades of virgin paper, especially as mills undergo incremental expansions over time.*

In the United States, the technology to deink relatively unsorted "office paper" for use in commodity-grade printing and writing papers made at large mills was commercialized only in the late 1980's.

In manufacturing these types of papers, deinked *pulp* generally costs more to produce than virgin bleached kraft pulp, especially when prices for recovered paper are high. Per-ton costs are even higher when deinked pulp made from recovered office paper is partially substituted for inexpensive virgin mechanical pulp used in lightweight coated groundwood papers. The overall economics of making *paper* with recycled content can be favorable when mills are expanding their paper production capacity and need more fiber, and when the cost of recovered paper is not extremely high.

A combination of higher costs and the ability to set prices in a tight market has led many, though not all, producers of printing and writing paper to charge price premiums for recycled content. Under certain conditions, price premiums may decline or disappear, as discussed on page 91.

c) Increased recycling as a strategy for positively influencing the dynamics of the paper market

Paper recycling holds a potentially powerful cost-containment feature that affects all users of paper, but is not recognized by most paper purchasers. The market price for new paper products is strongly related to the overall demand for paper compared to manufacturers' capacity to make new paper. *When capacity is high relative to demand, prices tend to fall*, as discussed in Chapter 1.

Paper users cannot themselves build more production capacity, but by supporting increased recycling, they can collectively create incentives for manufacturers to do so. Collecting additional used paper for recycling provides paper manufacturers with an expanded supply of fiber for making new paper and generally reduces their cost of using this material. Expressing a preference for recycled paper products that meet functional and economic needs increases the incentive for paper manufacturers to add incremental, recycling-based production capacity. As noted previously, recycling can often meet manufacturers' incremental needs for pulp more quickly, at a more appropriate scale, and at a lower capital cost than expansions of virgin pulping capacity. Growth in recycling-based paper manufacturing capacity is now outpacing growth in virgin paper production capacity.[12]

This strategy for changing the market requires not only that paper users collect their own paper for recycling and look for opportunities to purchase paper with recycled content, but that they strongly encourage others to do the same. As discussed on page 88, the advent of greater recycling in the United States is already creating lower prices for grades such as corrugated containerboard. Recycling extends the existing fiber base, providing U.S. paper manufacturers with an opportunity for additional growth in the global market.

III. IMPLEMENTATION OPTIONS

This section provides guidance for paper buyers and users on how to implement the Task Force's recommendations on recycling. The recommendations contain initiatives on both the supply side and the demand side of the recycling system, which ultimately must be balanced for recycling to work. Achieving success in implementation will therefore require a strong organizational commitment to all three recommendations.

Not all implementation options will be appropriate for all paper users. However, there should be one or more options in each category that allow all paper users to take action on each of the recommendations in a way that suits their organization's needs.

Expanding and Optimizing Paper Recycling Collection Programs

Whatever type of business you operate, one goal of initiating a paper recycling collection program is to optimize revenues from the sale of recovered paper and reduce your costs for solid waste collection and disposal. With the relatively high prices for recovered paper that are projected by experts through the end of the decade, many businesses can now achieve both of these goals by maximizing the volume of paper they collect.

The economics and practicality of setting up paper collection programs varies among different businesses and locations and must be determined on a case-by-case basis. Information resources that organizations can use to help plan or improve recycling collection programs are listed at the end of this section. Companies that provide recycling collection services can also help design separation and collection programs. Rising prices for recovered paper have made the paper collection business much more competitive, and service is improving. To create a successful program, it is still important for your organization to take the initiative. Some basic principles and guidelines to consider include the following.

- *Establish a baseline.* Understand your current waste management and recycling services, such as the amount of solid waste and recyclable materials your organization generates, the frequency and cost of refuse collection and any revenues earned for recycling collections.
- *Optimize value and volume*. Design a collection system that is convenient enough to generate a large volume of material while maintaining a level of separation that sustains the intrinsic value of the paper. The specifics of this approach will vary among different businesses and regions.
- *Enlist key supporters*. To start a business recycling collection program, people are required to put the basic elements of the program in place. Successful business recycling programs have been built both as top-down initiatives from senior management and as grassroots projects started by individual staff. In many large companies, building maintenance and purchasing are placed in separate divisions; clear support from senior management can help surmount these separations. The active participation of building management will also be critical for multi-tenant buildings, retail malls, etc.
- *Educate your co-workers*. Provide a clear explanation for why and how the recycling collection system is being implemented. Continue the education program after the program is running.
- *Track the markets*. To ensure that you are receiving a fair price for your used paper, stay informed of recovered paper market conditions. The Chicago Board of Trade makes information on recovered paper pricing available through an on-line service. Data on market prices are available in the trade publications listed at the end of this section. Recycling specialists in some state environmental or economic development agencies also publish regional market data.
- *Add more materials.* An office that generates primarily white paper may be able to add newspapers, magazines and corrugated boxes to its collection system. The converse is true for a retail store or restaurant. Bottles and cans, wood pallets and shipping materials and other recyclable items should also be considered.
- *Work with other local businesses.* Small businesses in the same neighborhood may be able to join together to create a "business recycling district" which would allow recycling collectors to provide better service at lower cost. Examples of such programs are provided in the next section.
- *Adjust your schedule for trash pick-up*. If possible, use the volume of materials diverted due to recycling to justify less frequent collection of refuse or use of a smaller container. Because it takes about the same amount of time to collect a small refuse container as it does a large one, a change in schedule may be necessary to see major cost reductions. Businesses that generate relatively small quantities of used paper on a daily basis may be able to develop a system that allows for pickup of a rolling container or bin once every two weeks or once a month.
- *Put it in writing*. Consider contracts with recycling collectors or paper manufacturers. Some paper recycling companies are beginning to offer long-term contracts to generators of recovered paper in order to provide an assured supply to mills. Some contracts have floor prices, which make revenue from sales of recovered paper more predictable. Such contracts are also being offered to municipal recycling collection programs. For large generators of corrugated boxes, for example, con-

tracts may offer a per-ton premium over the current market price for a grade of recovered paper. These premiums are not yet being offered for white office papers, but this could change. A requirement that the collector monitor and report information on market prices and volumes of materials collected can also be part of a service contract.

- *Consider "closing the loop."* Some manufacturers of recycled content paper are beginning to develop quasi- "closed loop" contracts. Under these agreements, the paper manufacturer buys all of your recovered paper at the market price and sells you paper with recycled content. The recycled content in the new paper that you buy is not necessarily the same fiber that was collected from your business. This type of arrangement may provide a mutual economic advantage to buyer and seller. The seller is more likely to obtain the full market value of the recovered paper. Transportation of new products and recovered paper to and from the mill may be made more efficient. This arrangement also creates a relationship in which the manufacturer can work with the paper user to reduce sources of contamination in the paper and increase the recyclability of paper being used. For large paper users it is conceivable that such contracts could include discounts on new paper prices or premiums for used paper collected, although to our knowledge this has not yet occurred.
- *Measure and report your progress.* Report volume and financial results to the purchasing and other relevant departments and to all employees participating in the program.

Business members of the National Office Paper Recycling Project lend their name and effort to spur office paper recovery through a range of activities.

Assisting in the Development of a Recycling Infrastructure

Organizations that distribute paper through their business activities to customers as packaging, products or vehicles for communication should actively work to increase the recovery of such paper. In some cases, efforts can be targeted specifically to an organization's own paper distributed into commerce. In others, the effort may more appropriately entail working with similar businesses or a range of other parties to facilitate greater recovery of a range of used paper, including an organization's own distributed paper products.

Below are several examples of steps that companies, government agencies and non-profit organizations have taken to facilitate recovery of the paper they distribute through their businesses. The feasibility of such efforts will vary with the type of paper, how it is distributed, the availability of a collection infrastructure and other factors. In virtually all cases, working with other organizations will be an essential aspect of any effort. It is rare that the organization distributing the paper would have the capability of recovering such material by itself. A major role that your organization can play is to catalyze, coordinate and facilitate actions taken in concert with others.

- Several regional telephone companies have worked with local communities to include used phone books in curbside and commercial recycling collection programs. These efforts have included working with recycling-based paper mills to ensure that there is a market for phone books when they are collected. In New York City, the NYNEX *Yellow Pages* includes information on the schedule for residential recycling collection and the materials that are collected, which include phone books. Phone companies also are buying directory paper with recycled content. Bell South and other utilities are using envelopes made from old phone directories for mailings to customers. This model may be appropriate for other companies that have the ability to provide information about recycling in the products they deliver to the public.
- Magazine and catalog publishers can work with others in their industry and in the recycling industry to spur recovery of used or overissue magazines. For example, the Magazine Publishers' Association has undertaken an effort to learn from recycling collection companies and paper manufacturers how changes in magazine design (e.g., binding methods, use of adhesives) and distribution practices can facilitate greater recovery.
- Companies that purchase and distribute large quantities of printing and writing paper through the mail or other means (e.g., financial services companies) can lend their support to efforts by businesses and municipalities to develop or enhance office and residential recycling collection programs for such

materials. For example, business members of the National Office Paper Recycling Project lend their name and effort to spur office paper recovery through a range of activities.

- Businesses have joined together in many communities, states and regions to share information on the practical aspects of running efficient recycling collection programs and to organize collection networks. A few examples of these programs are provided below; the endnotes provide details on how to obtain more information.
  - In Chicago and in northern Cook County, IL, public agencies have helped set up several commercial recycling collection routes for groups of small businesses. Due to improved collection efficiencies and the ability to put whole routes out to bid, these programs in most cases have cut recycling and waste disposal costs for the businesses they serve. The programs also allow for the collection of a very broad range of materials, including virtually all recyclable paper. Many of these programs are in a transition to being operated completely within the private sector or with the assistance of local non-profit organizations.[13]
  - In Lincoln, NB, a business group called Industrial Nebraskans for Organized Recycling Management set up drop-off sites within a business district to help businesses and residents recycle corrugated boxes and folding cartons in an economical fashion.
  - A non-profit organization, the New England Resource Recovery Association, has formed a company called the Business Recycling Corporation that arranges cooperative marketing and transportation services for businesses and institutions throughout New England.[14] By acting as a seller of materials for many businesses and towns, the Association can obtain higher prices for materials. By efficiently routing transportation through rural areas it can reduce the cost of getting materials to markets.
- Companies with extensive publicity and advertising resources can promote efforts to enhance the recycling infrastructure for specific categories of paper products, such as catalogs, direct mail, packaging, etc. Such companies should only make claims about the recyclability of specific paper products that are acceptable under Federal Trade Commission guidelines for the use of environmental claims in advertising.
- Companies that have a cost-effective mechanism for accepting their products back from customers can develop procedures to recycle them. For example, numerous regional phone companies and electric and gas utilities are recycling envelopes and billing statements returned to them by their customers; this fact is noted on return envelopes. Kodak receives single-use cameras back from customers when it develops the film inside the cameras. The paperboard packaging that is part of the camera is recycled and the plastic camera itself is reloaded with film or recycled.

Approaches to Buying Paper With Recycled Content

1. Getting started

A first step in increasing your organization's use of paper with recycled content is to assess purchasing opportunities. Purchasers should take stock of their organizations' functional and economic requirements in using paper. They should consider the potential to use recycled paper in all applications, including major and minor uses, paper products that are highly visible to customers or other important stakeholders, and grades of paper that will be relatively easy or challenging in adding recycled content.

Making meaningful progress over time requires a system for measuring purchases of recycled-content paper, although the degree of specificity required for this system will vary from company to company. Establishing a baseline that measures current virgin and recycled-content paper purchases is part of this process.

2. Defining recycled content

In the process of buying paper with recycled content, the purchaser must specify how recycled content should be defined. *Postconsumer* recycled content refers to "products or other materials generated by a business or consumer that have served their intended end uses, and that have been recovered or otherwise diverted from the solid waste stream for the purpose of recycling."[15] In other words, postconsumer materials are finished products that are collected from homes or places of work. Postconsumer paper does not include overissue publications and forms.[16]

In contrast, *preconsumer* material is defined as "materials generated during any step of production of a product, and that have been recovered from or otherwise diverted from the solid waste stream for the purpose of recycling, but does not include those scrap materials, virgin content of a material or by-products generated from, and commonly used within, an original manufacturing process."[17] For paper recycling, this means that trim from converting envelopes, paper plates and cups, boxes and cartons and printing runs counts as preconsumer material. Trim generated on the paper machine ("mill broke") that is returned directly to the papermaking process within the mill does not. The percentage of *total recycled content* in a paper product is simply the sum of the pre- and postconsumer fiber content.

Including preconsumer and postconsumer recycled content in paper are both desirable. The recommendations of the Paper Task Force place a higher priority on purchasing paper with postconsumer recycled content because this action will *directly* support business and community recycling collection programs and manufacturers that are diverting materials from solid waste. Almost all preconsumer paper scrap is already being recycled. The vast majority of used paper being disposed in landfills and incinerators comes from postconsumer sources. Additional perspective on definitions of recycled content is provided in the section on *Answers to Frequently Asked Questions* in this chapter.

The postconsumer definition has been established as a standard in the private marketplace after extensive public discussion among many parties involved in manufacturing and using recycled paper. The postconsumer definition is used by the federal government and thousands of state and local government agencies and private buyers. For example, all of the members of the Paper Task Force were using the postconsumer definition before the Task Force was established.

In paper, the percentage of recycled content can also be measured by *total weight* (the fraction of recycled content expressed as a percentage of the total weight of the paper sheet) or by *fiber weight* (the fraction of recycled content expressed as a percentage of the total weight of paper fiber in the sheet).[18] Since paper can contain 5% - 35% non-fiber materials such as fillers and coatings, for the same amount of recycled fiber in the paper sheet, the fiber weight definition will provide a higher percentage of recycled content than the total weight definition. The fiber weight definition is the most widely used. The level of recycled content in a specific paper product is usually stated as the average percentage of recycled content for a mill's output of that grade over a given period of time, such as a month or quarter.

3. Setting levels of recycled content

Purchasers that set out to buy paper with recycled content will quickly encounter the question of what is a "good" level of recycled content for a specific paper product. Maximizing postconsumer content is generally desirable because it also maximizes environmental benefits and does the most to support business and community recycling collection programs.

However, the appropriate goal need not be 100% recycled content — it depends on the product and the economic and functional needs of paper users. Many paper producers, particularly those making printing and writing grades, blend recycled and virgin fibers.

As a starting point for purchasers to use in setting, comparing and evaluating their own recycled content goals, Table 3 provides information regarding availability and current levels of recycled content in specific paper grades. Because the market will continue to evolve after this report is published, the last part of this section provides additional information resources that can be used to monitor developments in the market over time.

The availability of printing and writing paper with recycled content depends in part on customer demand; manufacturers of virgin printing and writing paper can add variable quantities of purchased deinked market pulp (DMP) to provide postconsumer recycled content. Deinked market pulp is usually made by independent companies that remove the ink and other contaminants from office paper and dry and sell the pulp to paper companies for blending with virgin fiber on their existing paper machines. In 1988 there were four deinked market pulp mills in the U.S. making a pulp suitable for use in printing and writing papers; by the end of 1997 there will be at least 18, making roughly 1.5 millions tons a year of DMP.[19] At 10% - 30% postconsumer recycled content, for example, this much DMP could be blended with virgin pulp to make a total of roughly 6 to 15 million tons of paper per year.

4. Action steps for effective purchasing of paper with postconsumer recycled content

The following are suggestions of ways in which purchasers might generally improve the effectiveness of their organizations' purchasing of recycled-content paper. These options can be used in different sequences and combinations.

- Be open to new products and be willing to reexamine traditional purchasing specifications, such as brightness, shade and the presence of minor impurities. Consider how these factors affect the basic functional requirements of the paper. Among printing and writing papers, for example, the majority of papers introduced in the market have an appearance that is identical to virgin paper, but some do not.
- Consider changing the specifications and design of paper products and packaging in order to facilitate cost reduction and the addition of recycled content. This approach may be especially applicable for corrugated boxes and folding cartons.
- Work with current and prospective paper suppliers to assess the availability and pricing of recycled-content papers in the marketplace. Develop the information resources to track new product introductions and other changes in market conditions.
- Based on an assessment of your needs, the availability of products in the marketplace and a dialogue with suppliers, set goals and milestones for purchasing paper with postconsumer recycled content. For example, goals could be set for specific levels of recycled content for individual grades of paper, either as minimum levels or as desired ranges. Or, a goal could be set for the use of a certain percentage of recycled-content paper across the organization.
- Develop a minimum postconsumer recycled content specification for a specific paper product. Buy paper from the suppliers that meet the specifications.
- Reward suppliers of recycled-content paper with additional business or develop a strategic alliance with a supplier of paper with recycled content. Within these alliances, purchasers and suppliers work together to achieve mutual long-term goals. Purchasers who take these steps send a strong signal to the market.
- Consider labeling your use of recycled-content paper, especially on products where your customers will appreciate your environmental initiative. Follow the Federal Trade Commis-

Table 3

Information on Recycled Content for Different Paper Grades in 1995

PAPER GRADE	USES	RECYCLED CONTENT RANGE	AVAILABILITY/COMMENTS
Commodity Uncoated Freesheet	Photocopy paper, fax paper, laser-jet computer print-out, business forms, white wove envelopes offset printing	10-35% postconsumer content and higher	More than 2 million tons in 1996, or about 15% of the market. Available with 50-70% post-consumer and 100% total recycled content on a more limited basis.
Specialty Uncoated Freesheet	Text and cover paper for books, letterhead, stationery, business cards, short printing runs (e.g.,invitations),etc.	10-100% postconsumer content, up to 100% total recycled content	A wide selection is available within this relatively small grade category; more limited availability at very high brightness levels.
Coated Freesheet	Catalogs,higher-end magazines, direct mail inserts, annual reports, commercial printing	10-30+% postconsumer content	Production depends partly on demand, since deinked market pulp is used to add recycled content.
Coated Groundwood	Magazines,catalogs	10-30% postconsumer content in 40 lb. and higher basis weights 10-20% postconsumer content in lighter basis weights	Production depends on demand due to the use of deinked market pulp. In lighter basis weights, 10% postconsumer content predominates.
Uncoated Groundwood	Newspaper inserts, some magazines,paperback books, some multi-purpose office paper and perforated computer forms	10-100% postconsumer content	Level of postconsumer content and availability depend on the type of paper.
Unbleached Linerboard	Corrugated boxes	0-100% total recycled content	Widely available; average recycled content of corrugated boxes (liner and medium) is 38% total recycled content,mostly postconsumer.
Mottled White Linerboard	Corrugated boxes	0-100% total recycled content	One recycled manufacturer; another starting up.
Corrugating Medium	Corrugated boxes	0-100% total recycled content	Widely available
Clay Coated 100% Recycled Paperboard	Folding cartons and other packaging	100% total recycled content; typically a minimum of 35% postconsumer content	Widely available
Solid Bleached Sulfate Paperboard	Folding cartons and other packaging	10-30% postconsumer content	Limited availability; depends in part on demand.
Coated Unbleached Kraft Paperboard	Folding cartons and other packaging	20-30% postconsumer recycled content	Two producers of this grade overall; both offer recycled content.

sion's guidelines (and, where applicable, state guidelines) on environmental claims in advertising and labeling postconsumer content.
- Systematically test the performance of paper with recycled content, as a way of overcoming misperceptions and myths about recycled-content paper.

As of mid-1995, many manufacturers of printing and writing paper were charging price premiums for recycled content. These premiums exist for a combination of reasons, which are discussed on pages 91-92 in the section on the economics of producing printing and writing paper with recycled content. Although price premiums are generally found only for recycled-content printing and writing grades and solid bleached sulfate paperboard, the reality is that they have arrived at a time when purchasers are already over-budget on paper due to recent price hikes. Under certain conditions, price premiums for these grades may decline or disappear over time. There is also some variability in pricing; several Paper Task Force members have negotiated some purchases of recycled-content printing and writing paper without price premiums.

In some cases, it may be possible to reduce costs in the paper purchasing system and then apply a portion of the savings to purchasing paper with recycled content. Some cost-saving steps may be possible under any conditions. However, others may be much more effective if employees and customers know that they are part of an overall policy to achieve a positive environmental goal, rather than just trying to cut costs. Some major paper users, such as BankAmerica Corp., have established buying paper with recycled content as a matter of corporate policy. Within this policy, the purchasing department can take a number of steps to cut costs and still fulfill its commitment. Initiatives to create offsetting cost reductions and other means of responding to price premiums may include the following.

- Do not pay the premium for the recycled-content paper (i.e., do not buy the paper), but signal to all current and potential suppliers that you will buy paper with recycled content if it is at or close to price parity with virgin paper. Be persistent. State your economic and functional needs clearly at the outset and then follow through when they are met.
- Work with suppliers to reformulate paper so that underlying production costs are less of an issue. For example, levels of recycled content may be reduced; it is better to accept a lower level of recycled content that you can afford than not to buy recycled content altogether due to increased prices. Where possible, switching from white to brown paper will likely cut costs and make possible the addition of significant levels of recycled content.
- Where possible given functional requirements, shift to a different grade of paper with lower costs (e.g., 83 brightness instead of 87 brightness photocopy paper, uncoated paper instead of coated paper, paper made from mechanical pulp instead of freesheet paper or a paper with a reduced basis weight). Use the savings to pay the premium for recycled content in that grade.
- Use the revenues from source reduction and better paper recycling collection programs to support payments for recycled-content paper. This approach will work for businesses that accumulate paper on their own premises, such as offices, rather than distributing it to customers, such as publishers.
- Work with suppliers to reduce the cost of other elements in the supply system, such as case packaging and ream wraps on photocopy paper used by large photocopying centers; use the savings to pay for the recycled content.
- Monitor indicators that will suggest whether price premiums for recycled-content paper should be increasing or decreasing, such as the price of the relevant type of recovered paper and the difference between the price of deinked market pulp and bleached hardwood kraft market pulp.
- Pay the premium. This may be easier to justify when customers especially appreciate or expect paper with recycled content, for a highly visible use of paper, or in cases when the cost of paper is a relatively small fraction of the total cost of the product.

Increasing the Recyclability of the Paper Your Organization Uses

Acquiring a consistent supply of relatively uncontaminated postconsumer recovered fiber is a major challenge to manufacturers of recycled-content papers, especially makers of printing and writing papers. Designing or purchasing products that can be more easily recycled after their use can help address this issue. By taking into account "recyclability" principles when buying, using or separating paper for recycling, businesses can expand the supply of postconsumer recovered paper. They can also potentially increase the revenue they receive for their own used paper they collect for recycling. Over time, many organizations taking these steps in the aggregate will enhance the practical and economic viability of the overall recycling system.

Contamination of recovered paper is generally a much greater problem for paper manufacturers that "deink" the recovered paper (i.e., printing and writing paper, tissue and newsprint manufacturers) than those that do not (i.e., paperboard manufacturers). Paperboard is generally stronger and thicker than paper, and in some cases appearance is not as critical. Among printing and writing papers, coated papers, especially in lighter basis weights, are the most sensitive to contaminants.

Modern deinking systems are designed to remove a wide range of contaminants, including polymer-based inks from photocopy machines, laser-jet printers and plain paper faxes, most paper dyes, bits of plastic, adhesive labels, magazine bindings, staples, paper clips, plastic envelope windows, paper coatings, and random dirt and debris. In addition, recovered paper is usually sorted before being baled and shipped to the deinking mill in order to remove obvious large contaminants. Deinking mills are striving to accept more contaminated grades of paper collected from offices because those grades are more abundant and less expensive. *All other things being equal, paper recycling mills would still prefer fewer contaminants in the recovered paper they buy*. Paper users should check with their recycling collectors or the mills that buy their recovered paper to determine their processing capabilities.

As problematic contaminants and ways of addressing them are identified, paper purchasers should use their position in the marketplace to initiate a dialogue among product designers, paper users, recycling collectors and recycling-based paper manufacturers. One example would be a discussion between large printers, ink manufacturers, deinking equipment suppliers and mill operators aimed at developing inks that are also easier to remove in deinking systems. *As solutions to contamination problems are developed, purchasers should work with their suppliers to implement them*. Some of the most problematic contaminants in recovered paper are listed below.

All other things being equal, paper recycling mills would still prefer fewer contaminants in the recovered paper they buy.

1. Printing and writing papers

- For printing and writing papers, the most problematic contaminants include "peel and stick" adhesive labels and hot-melt glues used in "perfect" bindings. Particles of chopped up adhesive that make it through the fiber cleaning process can become "stickies," which can attach themselves to parts of the paper machine or become imbedded in the paper itself. Stickies become tacky when they are heated. They can stick to parts of the paper machine, picking holes or starting tears in the paper sheet. They can also show up as small blemishes in the paper itself, or become attached to parts of printing presses or photocopy machines. While some repositionable labels may cause stickies, Post-It Notes™ are an example of this type of product that are not a problem.
- The presence of significant quantities of deep, brightly colored papers (e.g., goldenrod, cherry and neon colors) can cause a tint in deinked pulp. Pastel colors are not a problem.
- Most modern recovered fiber processing systems can remove plastic envelope windows with relative ease, but like all parts of the paper product that are not reused in the recycled paper sheet, they must be disposed as waste. Where possible, eliminating plastic windows is desired.
- Plastic envelopes (e.g., Tyvek™) can clog pumps and screens in deinking systems. Users of these types of envelopes should consider working with envelope suppliers to find a way that they can be tinted or otherwise identified to prevent being mixed in with office papers.

- Another contaminant mentioned by printing and writing paper manufacturers and makers of 100% recycled paperboard is plastic, ultraviolet-set coatings. These tough, shiny coatings are used on some magazines sold on newsstands and some folding cartons. These coatings fragment into tiny shards of plastic in the recovered fiber pulping process, which can be difficult to remove. Often aqueous coatings are used, which are more recyclable.
- Consider using uncoated paper in place of clay-coated paper in cases where functional needs can be met. Although the paper itself is not a contaminant, the clay coating must be removed and disposed in the deinking process, which reduces the amount of useful fiber per ton recovered by approximately one- third. Some manufacturers of recycled-content newsprint use magazines and catalogs in their deinking process, because the clay enhances ink removal and magazines contain brighter, higher-quality fiber than newsprint. However, the total demand for magazines at newsprint deinking mills in North America in 1995 was approximately 0.7-1.4 million tons per year, compared to total use of coated papers in magazines and catalogs of 6.4 million tons.[20] Magazines and catalogs are also recycled into tissue products.

2. Corrugated boxes

- The largest single contamination issue for paperboard manufacturers is waxed-coated corrugated boxes. The American Forest & Paper Association, the Fiber Box Association and several corrugated box manufacturers are working on developing standards for wax coating replacements that are more recyclable.

3. Folding cartons

- As more folding cartons are beginning to be collected for recycling in U.S. communities, paper mills are discovering that many of the non-paper materials added to the package to make it more functional and convenient are now having to be screened out and disposed. Such items include plastic handles, spouts, tear tapes, coatings and metal tear strips. Over time, packaging designers should work to increase the recyclability of such packages while maintaining functional performance.
- Folding cartons made using wet-strength paperboard (e.g., beverage carrier cases) can be difficult to recycle because the wet-strength additive inhibits pulping. This is an issue for recycling box clippings as well as packages themselves. One manufacturer of CUK paperboard has developed a comparatively repulpable wet-strength additive; this formulation is being made available to the entire industry.

In some cases, reducing the presence of a certain contaminant will provide an immediate economic return for paper users. For example, office paper with less colored paper in it sells at a higher price in the recovered paper market. Purchasing less colored paper can also cost the paper user less. Paper users and mills should both benefit when they can communicate about the presence of certain contaminants in recovered paper and how recycling collection systems are operated. Other changes will have to be diffused throughout society before they have their full impact on the recycling system. As certain materials such as brightly colored papers and adhesives are identified as contaminants, manufacturers are developing alternatives that can be handled more easily in deinking and fiber processing systems. Purchasers can help accelerate the introduction of such products into the marketplace.

Information Resources For Purchasers

Publications:

BioCycle — Monthly magazine covering a wide range of issues in recycling and composting; publishes a comprehensive annual survey, “The State of Garbage in America,” every spring. $63 per year. 419 State Avenue, Emmaus, PA 18049.

Paper Recycler — Industry newsletter with broad coverage of market and manufacturing issues in recycled paper, paperboard and packaging. Provides market prices paid by mills, by region, for approximately 22 recovered paper grades. Published monthly; $347 per year. Miller Freeman, Inc., 600 Harrison St., San Francisco, CA 94107. Miller Freeman publishes a wide variety of newsletters and books relating to the paper and forest products industries.

The Jaakko Pöyry *Recycled Gradefinder* — A comprehensive guide that seeks to list all of the printing and writing papers with recycled content available in the United States, which amounts to several hundred different products and brands. Information on the grade of paper, brand name, distributor, manufacturer, total recycled content, postconsumer content and brightness are listed. Published four times a year; $90 for an annual subscription. Jaakko Pöyry Consulting, Inc., 560 White Plains Road, Tarrytown, NY 10591.

Recycled Paper News — Monthly newsletter covering new product introductions, public policy, environmental marketing, product retailing and environmental issues for recycled paper products. $235 per year. 6732 Huntsman Blvd., Springfield, VA 22152.

Recycling Times — Weekly newspaper-format publication covering recycling and market and public policy issues for a spectrum of recyclable and compostable materials (paper, plastics, glass, metals, yard trimmings, etc.). Provides market price estimates paid by processors and manufacturers for a range of materials and regions. Published by the Environmental Industry Associations, the trade association for the private solid waste management industry, which also publishes *Waste Age*, a monthly periodical dedicated to solid waste management in general. $99 per year. 4301 Connecticut Avenue NW, Suite 300, Washington, DC 20008.

Resource Recycling — A monthly magazine offering up-to-date coverage and investigative journalism on innovations in recycling, with a focus on paper, plastics and emerging programs and collection and processing technologies. Also covers composting topics. $42 per year. 1206 NW 21st Avenue, Portland, OR 97209.

The *U.S. Environmental Protection Agency* offers a range of publications and programs relating to recycling and solid waste management. A list of publications can be obtained by writing to: RCRA Docket (5305 SW), U.S. EPA, 401 M Street SW, Washington, DC 20460.

Organizations and Programs:

Chicago Board of Trade. In October 1995, the Chicago Board of Trade established a "Recyclables Exchange" for recovered paper, glass, PET and HDPE plastic bottles and other materials. The exchange is an on-line electronic bulletin board that can be used to buy and sell materials and to check market prices. As a record of trades is accumulated, data on market prices are aggregated and made available.[21] A subscription to the complete on-line service that allows buying and trading costs $1,000 per year; information on market prices only is available free by dialing into the system using a computer with a modem. Recyclables Exchange, 141 W. Jackson Blvd., Chicago, IL 60604; (312) 341-7955.

National Office Paper Recycling Project. Founded by the U.S. Conference of Mayors and businesses including BFI, Hewlett-Packard, Kodak, Waste Management, Inc., Xerox and a number of paper companies, this program provides a wide range of practical resources for offices of all types that want to make their paper recycling programs more effective. Service and materials include manuals on setting up and improving collection programs, posters and other promotional materials for use in offices, and quarterly seminars held in different U.S. regions focusing on problem-solving and improvements in office recycling collection programs. 1620 Eye Street NW, Washington, DC 20006; (202) 223-3088.

National Recycling Coalition (NRC). The NRC is a non-profit organization committed to maximizing recycling along with source reduction, reuse and composting. The NRC's diverse membership includes private companies, non-profit organizations, government agencies and individuals. Thirty-one state recycling organizations are part of the NRC as affiliates or associates. Major NRC projects include a national recycling "congress and exposition" held every fall; the Recycling Advisory Council, a policy-development group; ReTAP, a recycling technology assistance program conducted with the Clean Washington Center and other organizations; a number of committees and councils; and the Buy Recycled Business Alliance (BRBA). As of November, 1995, the BRBA included more than 1,400 companies and 5,000 purchasing managers committed to purchasing products with recycled content. NRC, 1725 King St., Suite 105, Alexandria, VA 22314; (703) 683-9025.

Recycled Paper Coalition. This group includes approximately 200 businesses committed to buying paper with postconsumer content, including large corporations and small firms in financial services, retail/wholesale, health care, consulting, law, manufacturing, utilities, printing, non-profit, government, paper and office supplies and other sectors. Founding members include BankAmerica, Pacific Gas & Electric, Chevron, Pacific Bell, Safeway, George Lithograph and Wallace Computer Services. Members commit, via the CEO's signature, to implementing a comprehensive paper-purchasing program, to giving preference to competitively priced recycled paper products and to working with paper and equipment manufacturers to increase the percentage of postconsumer content in recycled paper.[22] In 1994, the postconsumer recycled content fraction of overall paper purchases by coalition members was estimated as at least 80,000 tons.[23] Chapters exist in northern, central and southern California, Texas and Chicago; a chapter is being organized in New York. Within these different regions, contact:

- Mindy Grant, executive director, Recycled Paper Coalition, 3921 E. Bayshore Road, Palo Alto, CA, 94303; (415) 985-5568
- Gregory Voelm, 3524 Dutch Way, Sacramento, CA 95608; (916) 944-4218
- Jennifer Pinkerton, 315 W. 9th St., Suite 312, Los Angeles, CA 90015; (310) 333-4350
- Janine Ablan and Robert (Bob) Kee, Bank of America Texas, PO Box 619005; Dallas, TX 75265; (214) 651-2750 or (214) 444-5033
- Liz Claudio, Environmental Law & Policy Center of the Midwest, 203 N. LaSalle St., Suite 1390, Chicago, IL 60601; (312) 759-3400
- Linda Descano-Nelson, vice president, environmental affairs, Salomon, Inc., Seven World Trade Center, 43rd Floor, New York, NY 10048; (212) 783-6928

The U.S. Federal Trade Commission has developed guidelines for the use of environmental claims in advertising, including claims regarding a product's recycled content or ability to be recycled. Available from FTC, Public Reference Branch, Room 130, 6th and PA Ave., NW, Washington, DC, 2058; (202) 326-2222.

The U.S. Environmental Protection Agency has developed guidelines for federal purchases of different grades of paper with recycled content; the federal government is the largest purchaser of paper in the country.[24] In 1993, the White House issued Executive Order 12873, which requires that federal agencies purchase printing and writing papers with specified minimum levels of postconsumer recycled content. A revision of the EPA's guideline, which was first published in 1988, is scheduled for release in early 1996.

For more information on the EPA guidelines and supporting materials, call the RCRA Hotline; (800) 424-9346, or (703) 412-9810 in the Washington DC metro area. The Office of the Federal Environmental Executive can provide copies of the Executive Order and additional information; c/o U.S. EPA, Mail Code 1600, 401 M Street SW, Washington, DC 20460; (202) 260-1297.

Numerous state and local environmental protection, economic development and purchasing agencies have materials or services available on a wide range of recycling topics.

IV. GENERAL CONCLUSIONS IN SUPPORT OF THE RECYCLING RECOMMENDATIONS

Environmental Comparison of Recycled and Virgin Fiber–based Systems

The Task Force has compared energy requirements and environmental releases from 100% recycled fiber-based and 100% virgin fiber-based systems. Each system includes analogous activities in the acquisition of fiber, pulp and paper manufacturing and disposal of residuals. We have taken the comprehensive approach of examining entire systems, rather than limiting our comparison only to the recycled vs. virgin manufacturing processes or recovery vs. waste-management systems alone. The systems approach allows us to better assess the full range of environmental consequences that follow from the choice to produce recycled-content paper and recover and recycle used paper, as opposed to producing virgin paper, disposing of it and replacing it with new virgin paper.

We recognize that paper often contains recycled content at levels lower than 100%. By comparing 100% virgin and 100% recycled papers, we can assess the relative energy use and environmental releases of each type of fiber arising from its acquisition, manufacture, use and post-use management by various means. Environmental attributes of paper containing intermediate levels of recycled content would fall between the estimates provided in this study for the 100% virgin and 100% recycled products.

1. Scope of the comparison

For the *recycled fiber-based system*, we have examined: used paper collection, transport of the recovered paper to a material recovery facility (MRF), processing of the material at the MRF, transport of processed recovered material to the manufacturing site, manufacturing of pulp and paper using recovered fiber, and disposal of residuals from MRF operations and paper manufacturing.

For the *virgin fiber-based system*, we have included: harvesting of trees and transport of logs (or chips) to the mill, debarking and chipping, manufacture of pulp and paper using virgin fiber, collection of the paper after its use as part of municipal solid waste (MSW), transport of the waste to MSW landfills and waste-to-energy incinerators, and disposal or processing of the waste at such facilities.[25]

The environmental data gathered by the Task Force on the recycled and virgin fiber-based systems include energy use and environmental releases in the form of solid waste output, releases in several categories of air emissions and waterborne wastes, and water use/effluent flow in manufacturing. The Explanation of Key Terms and Abbreviations included at the end of this report provides definitions for the specific parameters examined by the Task Force. In addition, readers should refer to pages 178-180 of Chapter 5 for a more detailed description of these parameters and their environmental significance. Below we elaborate on our examination of two specific categories of environmental parameters: energy use and emissions of greenhouse gases.

In examining energy use, we considered both *total energy* — that generated from combustion of all types of fuels, including fuels derived from wood by-products (bark and pulping liquors at pulp mills and paper in incinerators), as well as electricity purchased from utilities — and *purchased energy* which represents only energy generated from combustion of purchased fossil fuels (that is, excluding combustion of wood-derived materials) and purchased electricity. The analysis also incorporates environmental releases and solid waste generation associated with the operation of powerplants that produce electricity used in recycled and virgin manufacturing processes.

Purchased electricity may be generated by a variety of energy sources, including fossil fuels (coal, oil, natural gas), nuclear power and hydropower – each of which has its own set of associated environmental impacts. On a national level, about 68% of electricity is produced from combustion of fossil fuels. In our analysis therefore, we have also indicated the fraction of purchased energy used in the virgin and recycled systems that is *fossil fuel-derived*. The relative consumption of fossil fuels by the different systems is an important environmental consideration: Consumption of fossil fuels contributes to the depletion of a natural resource, while fossil fuel extraction and transportation can also damage natural resources through mining activities (for example, strip-mining for coal) and accidental releases of raw fuels or other pollutants to the environment (for example, oil spills, refinery explosions, leaks from natural gas pipelines). Fossil fuel extraction, refinement and combustion also require energy and entail releases to the environment; estimates of these environmental parameters have been incorporated directly into our quantitative analysis.

In our analysis, the difference between the amounts of total and purchased enery used by a system represents the amount of energy generated from wood-derived fuels (bark, pulping liquors and used paper). For several of the paper grades we examined, the virgin fiber-based system uses more total, but less purchased, energy than the recycled fiber-based system (see Section V). Such a system consumes less fossil fuel and hence entails fewer of the environmental impacts just described; but it also consumes greater wood resources, which has environmental implications with respect to forest management that are discussed in Chapter 4.

Our accounting for *greenhouse gases* (specifically, carbon dioxide (CO_2) and methane emissions) also requires some elaboration. The environmental concern associated with such emissions is their association with the so-called "greenhouse effect" linked to global climate change. In assessing these emissions, we compared the virgin and recycled systems with respect to both *total* and *net* greenhouse gas emissions. CO_2 and methane emissions are accounted for somewhat differently, as follows:

CO_2: Emissions of CO_2 derived from burning wood-derived materials (bark and pulping liquors in pulp and paper mills, and paper in incinerators) do not result in a *net* increase in such emissions, because the trees from which these materials were derived absorbed the equivalent amount of CO_2 in the process of growing.[26] In contrast, emissions of CO_2 derived from the combustion of fossil fuels do result in a net increase. Hence, wood-derived CO_2 emissions are counted in *total*, but not *net*, greenhouse gas emissions; fossil fuel-derived CO_2 emissions are counted in both *total* and *net* greenhouse gas emissions.

Methane: Methane emissions from landfills are the only significant source of methane in our systems comparison. Decomposition of paper-based materials in landfills results in emissions of both CO_2 and methane. The CO_2 emissions are accounted for as just described: they contribute to *total* but not to *net* greenhouse gas emissions, because they are offset by an equivalent amount of CO_2 originally absorbed by the trees from which the paper was made. However, emissions of *methane* need to be accounted for differently. Methane is a much more potent greenhouse gas than is CO_2, with one pound of methane emissions representing the equivalent of 69 pounds of CO_2.[27] That is, each pound of methane contributes 69 pounds of greenhouse gas emissions *when expressed as CO_2 equivalents*. Only one pound of these emissions was derived from CO_2 originally absorbed by the trees used to make the paper; hence, all 69 pounds are counted in *total* greenhouse gas emissions, while 68 pounds are counted as *net* greenhouse emissions. Both *total* and *net* greenhouse gas emissions are expresed in terms of *CO_2 equivalents*.

Except for energy use in harvesting trees and transporting logs, the environmental effects associated with obtaining virgin fiber from trees have not been considered here, due to their largely qualitative nature. As discussed in Chapter 4, intensive management of forests for fiber and wood production can have significant biological and ecological consequences, such as effects on biodiversity, wildlife habitat and natural ecosystems. Such consequences are an important difference between recycled fiber and virgin fiber-based systems.

Because an increase in the use of recovered fiber by paper mills means a lower requirement for pulpwood, recycling extends the fiber base and can help to conserve forest resources. Moreover, the reduced demand for virgin fiber achieved through recycling will generally reduce the overall intensity of forest management required to meet a given level of demand for paper. In so doing, it can help to foster changes in forest management practices that are environmentally beneficial. For example, pressure may be reduced to convert natural forests and sensitive ecological areas like wetlands into intensively managed pine plantations, and more trees may be managed on longer rotations to meet demand for solid wood products rather than fiber.

2. Results of the comparison

The Task Force compiled data for several different grades of paper and paperboard products: newsprint made using either virgin thermomechanical pulp (TMP) or recovered deinked newspapers; corrugated boxes made using either virgin unbleached kraft linerboard and semi-chemical medium or recovered corrugated boxes; office papers made using either virgin uncoated freesheet or recovered deinked office paper; and paperboard used in folding cartons made using either virgin pulp (coated unbleached kraft or solid bleached sulfate) or non-deinked recovered paper. Although the Task Force did not make purchasing recommendations for newsprint, we thought this grade was important to examine because it is collected in almost all residential curbside recycling collection programs.

This analysis shows clear and substantial environmental advantages from recycling all of the grades of paper we examined. Figures 2 and 6-9 and Appendix A provide the data supporting this finding. **Figure 2**, which shows findings for virgin and recycled newsprint systems, is shown here as an example; additional figures are provided in Section V. The figures allow a comparison of the energy use and environmental releases associated with the recycled and virgin fiber-based systems for each paper grade. The tables in **Appendix** A provide the underlying data on the magnitude of each energy and environmental parameter examined, for each component activity that comprises the recycled fiber-based system and the two virgin fiber-based systems (one involving landfilling and the other waste-to-energy incineration).[28]

There are several exceptions to the general environmental finding just stated: (1) While the recycled fiber-based systems require smaller amounts of *total* energy than the virgin fiber-based systems, for three of the five grades examined here (office papers, corrugated boxes and coated unbleached kraft (CUK) paperboard used in folding cartons) the virgin fiber-based system requires less *purchased* (and *fossil fuel-derived*) energy. (2) In the case of corrugated boxes and CUK paperboard, sulfur oxide emissions are lower for the virgin fiber-based system. This is a direct result of the greater use of fossil fuel-derived energy by the recycled fiber-based system for these grades; sulfur oxide emissions are strongly correlated with fossil fuel combustion. (3) In the case of newsprint, the virgin fiber-based system, which involves making newsprint using thermomechanical pulp (TMP), results in lower releases of two water pollutants (biochemical oxygen demand, or BOD, and suspended solids) and generates less effluent in the manufacturing process, compared to the recycled fiber-based system.

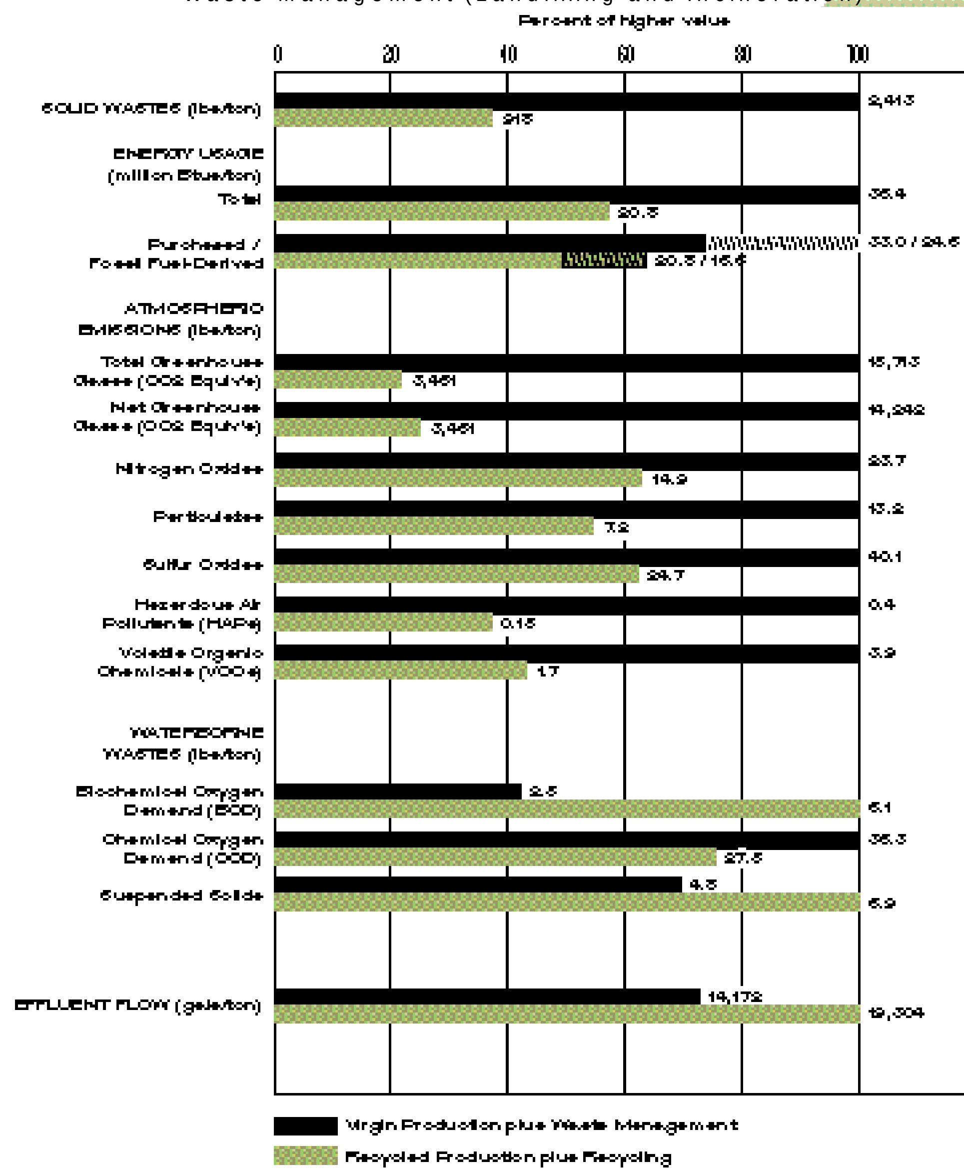
The strong environmental advantages attributable to recycling hold true despite the exclusion from the model, due to a lack of data, of several types of energy use and environmental releases associated only with the virgin system. These include, for example, the energy and environmental releases associated with forest management other than harvesting; releases to the air and water from landfills other than carbon dioxide and methane emissions; releases to the air from incinerators other than carbon dioxide, sulfur oxides, nitrogen oxides and particulates; and releases from ash landfills. In addition, certain assumptions were made in the model that overestimate energy use and environmental releases for the recycling system.[29]

3. Energy used in transportation vs. manufacturing

Several specific results from the comparison are worth noting, as they are somewhat counter to commonly held perceptions about recycling. First, it is often noted that collection and transport of materials for recycling often requires more energy and hence generates larger releases of pollutants from vehicles than does collection of municipal solid waste for disposal in landfills or incinerators. Our analysis is consistent with this finding, but also shows that this use of energy (and its contribution to envi-

Figure 2–Newsprint

Average Energy Use and Environmental Releases for Managing Newsprint by Recycled Production + Recycling vs. Virgin Production + Waste Management (Landfilling and Incineration)*



*assumes the national proportions of waste (after recycling) managed by landfilling (79.7%) and incineration (20.3%)

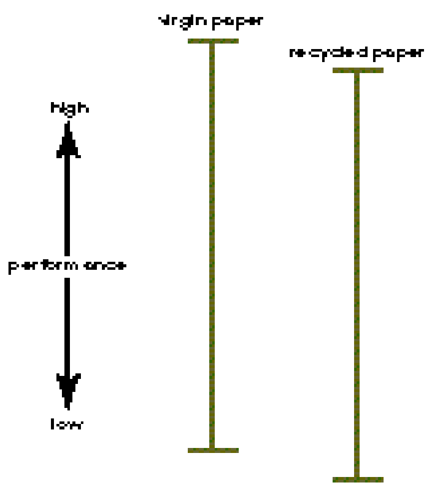
mental releases) is quite small in comparison to the nergy used in manufacturing.

As shown in the tables in Appendix A, the reduction in total manufacturing energy consumption resulting from using recovered paper rather than virgin materials is much larger than the increase in energy required for collection and transport of recovered materials relative to municipal solid waste. Indeed, for all grades of paper and for both virgin and recycled-fiber systems, manufacturing energy is the predominant use of energy by a large margin. Materials and residuals collection, processing and transport are all relatively small by comparison.

Another factor often neglected in assessing virgin fiber-based systems involves the amount of wood in the form of trees that must be harvested and transported to serve as a source of raw material. Wood in harvested trees contains approximately 50% moisture. In addition, wood pulping processes have yields that are considerably less than 100%; bleached kraft pulping yields are on the order of 45%, unbleached kraft yields are approximately 57% and mechanical pulp yields are 80-95%. The combination of these two factors means that from 2 to as many as 3.5 tons of trees must be harvested to produce one ton of pulp. The har-esting and transport energy per ton of pulp, erefore, is relatively high even in comparison to vered paper collection and transport.

Figure 3

Conceptual Comparison of the Range of Virgin and Recycled Paper Performance



Source: Gary Chaplin, Xerox Corp., Paper Task Force Expert Panel No. 4, July 1994

4. Important caveats

The details of the Task Force's model, data and assumptions are included in Appendix A and White Papers Nos. 3, 10A, 0B and 10C. Some important caveats need to be kept in mind en considering the findings just presented.

general, the data cited and presented in this chapter represent e (mean) values, or estimates intended to be representative of the facilities and activities being characterized, and the comparisons will be valid only for "typical" activities or facilities. Due to the time- and site-specific variation in much of the data presented here, caution should be exercised in applying these average data to characterize the environmental attributes of individual facilities or activities. The environmental characteristics of the types of activities and facilities examined here will virtually always show considerable variation. Average data may therefore overstate or understate the magnitude of a given environmental parameter for a specific activity or facility. While the data presented here are useful in indicating general or likely attributes, they should be subjected to further examination and confirmation if used in a more specific manner or setting than intended here.

As discussed in Chapter 1, however, in most cases average data are most appropriate for our purposes, because we are most interested in comparing typical activities and facilities, not 'best case" or "worst case" ones. For example, most purchasers do not know or cannot designate the mills from which they buy paper. The use of averages is appropriate in this case. By following conclusions drawn from average data, many purchasers, acting in the aggregate, will make decisions that on balance benefit the environment. For purchasers who do know from which mills they buy, Chapter 5 presents options for evaluating the environmental performance of individual manufacturing facilities.

No attempt is made here to assess the magnitude of actual environmental impacts that arise from the energy use and environmental releases; only their quantity is reported. Actual impacts depend on site-specific and highly variable factors, such as rate and location of releases, local climatic conditions, population densities and so on, which together determine the level of exposure to substances released to the environment. Such an assessment would require a detailed analysis of all sites where releases occur, which is well beyond the scope of this project (and indeed virtually any analysis of this sort). Our comparison here is of necessity limited to a quantitative comparison of data on the magnitude of energy use and environmental releases associated with the systems examined. The rationale for this approach is discussed at more length in Chapter 1.

Overall, we believe this is a conservative analysis with respect to the recycled fiber-based systems. The level of support for the findings is more than sufficient to ensure that their use by businesses making purchasing decisions will, in the aggregate, have a positive impact on the environment.

The Impact of Recycled Content on the Functional Performance of Paper Products

As discussed in Chapter 1, the functional requirements of different paper products vary widely, as do the physical properties of the different types of fiber used to make these paper products. For example, the linerboard used in a corrugated box places a premium on strength, while clay-coated groundwood paper used in magazines is designed to optimize properties such as a good printing surface, light weight and opacity.

Compared to the same type of virgin fibers used in the same application, recycled fibers have different properties. The differences may be large or small, depending on the application and how the recycled fibers are processed. Generally speaking, recycled fibers have reduced bonding potential compared to their virgin counterparts, which tends to reduce strength and requires compensation in the manufacturing process. In some circumstances, however, recycled fibers may also impart desired qualities to the paper sheet, such as smoothness and dimensional stability.

While the details vary for different paper grades, the Task Force has found that large quantities of recycled-content papers are available that meet specifications and perform comparably to virgin paper in the major grade categories covered in this report. In other words, *the quality of paper with recycled content is generally not a barrier to purchasing at levels of postconsumer recycled content that are now available*. To consider the performance comparison for virgin and recycled-content paper, it is important to bear in mind that for a given grade, the quality of both recycled and virgin paper varies over a range, as shown in Figure 3.

At the very upper end of the spectrum, the highest-quality virgin paper may have a slight advantage over the highest-quality recycled paper, but there are many recycled-content papers that perform as well as virgin paper and some that perform better than their virgin counterparts. The age, capabilities and operation of papermaking equipment have a greater impact on the properties of the finished paper than its recycled or virgin content.

Papermakers adjust for the differing properties of recycled fiber in numerous ways in the manufacturing process. In some cases, particularly for printing and writing papers, recovered and virgin fibers are blended. The compensations and adjustments for using recovered fiber do require capital and operating expenditures in some cases, but they also avoid certain capital and operating expenditures on the virgin production side (for example, having to build and run a virgin pulp mill). The economic tradeoffs for paper manufacturers in using recycled versus virgin fiber are discussed later in this chapter and in White Paper No. 9. Many of the adjustments made on the paper machine to compensate for the properties of recycled fiber are analogous to those made to compensate for attributes of different tree species, for example.

The ability of papermakers to compensate for the negative properties of recycled fiber and enhance the positive traits has developed over time. Manufacturers have decades of experience working with recycled fibers in linerboard, corrugating medium, recycled paperboard, tissue and some high-value printing and writing paper grades. In contrast, the addition of recycled content in commodity-grade printing and writing paper at large, integrated paper mills is a phenomenon in the United States of the last five years.

The Task Force has found that large quantities of recycled-content papers are available that meet specifications and perform comparably to virgin paper in the major grade categories covered in this report.

The Economics of Paper Recycling

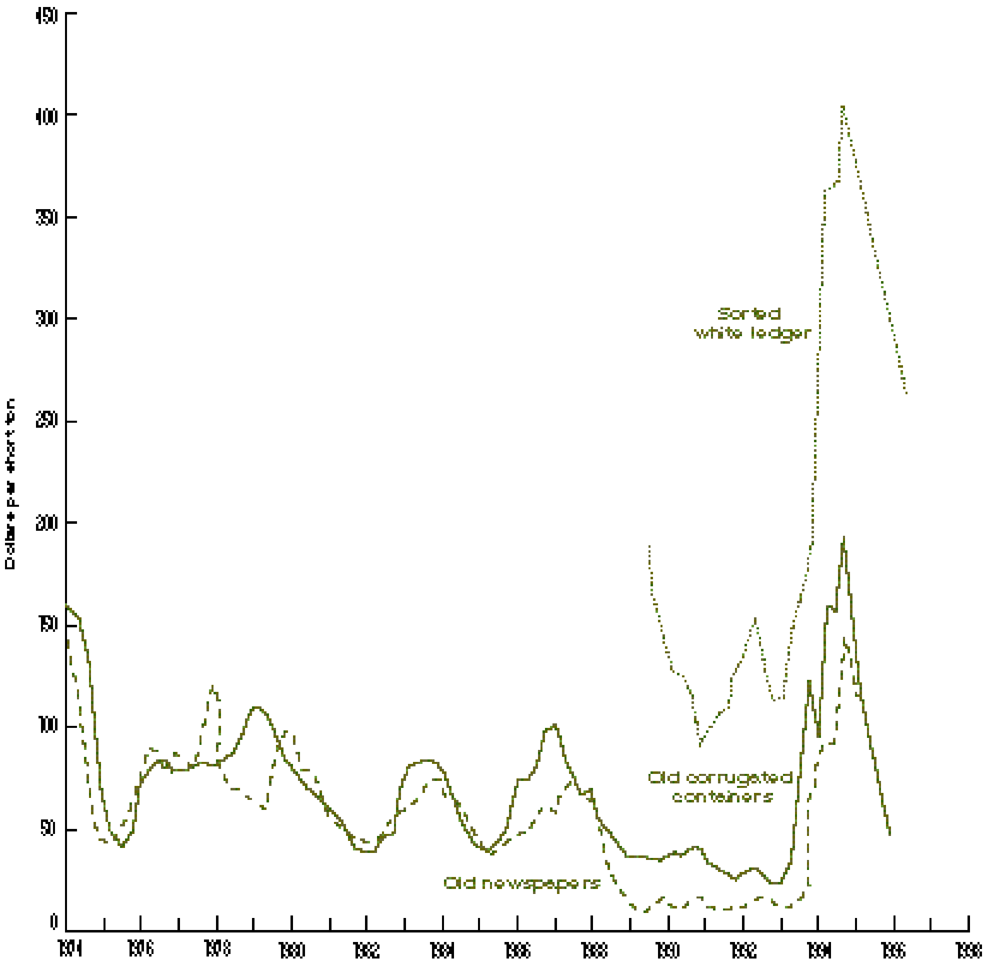
The Paper Task Force has identified three key themes from its research on the economics of paper recycling.

- The market price of recovered paper plays an important role in determining the comparative costs of paper recycling as an alternative to traditional forms of solid waste management.
- The price of recovered paper is also a key determining factor in the comparative economics of producing virgin and recycled-content paper. When recovered paper prices are within their historical range, producing paper with recycled content is less expensive than producing paper with virgin content for several major paper grades. This is especially true when paper mills are undergoing incremental expansions of capacity.

Figure 4

Recovered Paper Prices, U.S. Quarterly Average Prices Paid by Mills, in 1995 Dollars

(No. 6 old newspapers, old corrugated containers, sorted white ledger paper)



Source: Resource Information Systems, Inc., 1995

- By expanding the supply of fiber available to make paper and by expressing a preference for paper with recycled content, paper users can, in the aggregate, positively affect the dynamics of the market for new paper products.

1. Recovered paper prices and recycling collection and solid waste management costs

The market price of recovered paper has consequences for the economics of recycling compared to solid waste management and the comparative cost of manufacturing recycled and virgin paper. The recent history of paper recycling in the United States indicates how the price of recovered paper reflects changes in the overall recycling system.

From 1990 to early 1994, prices for recovered paper were very low, due to an excess of supply over demand. Many residential and commercial recycling collection programs started up during this time, and the 1991-1992 recession depressed demand for new paper products. These new collection programs were the result of rapidly rising disposal fees in some regions, government regulation of landfills and other public sector initiatives and the popularity of recycling among American citizens. Mills that were using recovered paper in this period benefited from the low prices. Some posted good operating profits even through the recession, outperforming predominantly virgin paper companies. Recycling collectors, on the other hand, earned reduced revenues per ton for the materials they collected.

Spurred by the abundance of inexpensive recovered fiber, consumer demand and technological advances in recovered-fiber processing systems, in the late 1980's paper manufacturers began installing large increments of additional deinking and recovered-fiber processing capacity. The timing and economics have varied for different grades of paper, but overall "...the paper industry in the second half of the 1990's will change more dramatically than it has in the previous 50 years. The structural impacts of recycling on the pulp and paper industry will mean a decreasing reliance on tree cultivation, a rethinking of the size of mills, new attitudes on locations of mills and strong recovered paper grade markets...".[30] Due to the installation of new paper recycling capacity, the recovery of the U.S. economy and growing worldwide demand for paper, by mid-1995, the situation in recovered paper markets was the reverse of that in the early 1990's.

Figure 4 shows U.S. quarterly average prices paid by paper mills from 1974 to September 1995 for three major grades of recovered paper, old newspapers, old corrugated containers and sorted white ledger paper (a relatively clean grade of postconsumer white paper collected from offices and similar sources). The prices charted in Figure 4 are adjusted for inflation. As the figure shows, from late 1993 to mid-1995, real prices for these three paper grades ranged between exceptional lows and highs. In the fall of 1995, recovered paper prices fell sharply from their mid-1995 peak, as shown previously in Table 2. Experts project that recovered paper prices will vary around a trend price that is significantly higher on average than during the 1989-1993 period.

The costs of recycling collection and processing compared to the costs of garbage collection and transfer plus landfilling or incineration vary greatly depending on local conditions and how the recycling program is designed. For example, across the United States, landfill disposal charges ranged from $10 to $140 per ton in 1994.[31] On a regional basis, incinerator tip fees are almost always higher than landfill fees. Except in areas where disposal is very expensive, collection costs are usually greater than disposal fees, for both refuse and recyclable materials.

Economically and practically, paper is one of the best materials to collect for recycling, due to its abundance, easy identification, and ability to be compacted (unlike aluminum, different types of plastic containers and glass, respectively). The economic benefit of recycling collection is that it provides revenues from the sales of materials and avoids the cost of disposing of waste in landfills or incinerators. Recycling adds costs to local waste management systems when recycling collection duplicates, rather than replaces, regular refuse collection. This is particularly an issue for conventional residential curbside collection programs.

The large majority of paper collected for recycling now comes from the commercial sector, where the economics of recycling are generally positive. The key to cost-effective collection of additional volumes of used paper will be increasing the efficiency of collecting from dispersed sources, such as homes, apartment buildings, small businesses, retail strip malls, restaurants, light manufacturing districts, etc. In both the residential and commercial sectors, collecting additional grades of paper that now have available markets — such as corrugated boxes, mail, white papers, magazines, catalogs and folding cartons — can increase collection volumes and efficiency.

Residential curbside collection is a large and relatively untapped source of used paper aside from newspapers. In 1988, there were approximately 1,000 curbside recycling collection programs operating in the United States; by 1994 one survey counted 7,265. By these estimates, curbside recycling services were available to 108 million people in 1994, or 41% of U.S. households.[32] Municipalities and recycling-collection companies are taking a number of steps to reduce duplication and make their curbside recycling programs more cost-effective, including redesigning recycling-collection trucks, optimizing recycling and refuse-collection routes and schedules, and collecting additional materials, especially paper.[33] Surveys of U.S. cities show that as the amount of material collected in recycling programs increases, the cost per ton decreases, due to better utilization of labor and equipment.[34]

Due to increased efficiencies and higher prices for recovered materials, in 1995 a number of cities implemented curbside recycling programs with little or no increased costs over their existing refuse-collection and disposal systems.

Due to increased efficiencies and higher prices for recovered materials, in 1995 a number of cities implemented curbside recycling programs with little or no increased costs over their existing refuse-collection and disposal systems. These cities included Fayetteville, AR, Cincinnati, OH, and Austin, TX.[35] Seattle, a city with a longer-established recycling program, will save approximately $5 million in 1995 due to its curbside recycling and composting collection programs compared to what it would otherwise have spent on municipal solid waste disposal.[36] Numerous cities in the province of Ontario have been operating curbside recycling programs since the late 1980's. As five-year contracts for these programs and others in Canada expire and are being renegotiated in 1995, one survey found an average 45% decline in fees.[37] There are undoubtedly still many cities with readily available opportunities for achieving reductions in the costs of their recycling programs.[38]

The change in recovered paper markets also provides opportunities for paper users in the commercial sector. Not only have recovered paper prices risen substantially, there is much more competition among companies providing recycling services. Some large recycling-collection companies are now offering long-term contracts to municipalities and businesses for their recovered paper. These contracts have guaranteed minimum prices that are substantially higher than the low prices of the early 1990's. Some large generators of used corrugated containers, for example, are also receiving a premium over the market price for old corrugated containers.

2. The cost of manufacturing paper with recycled content

Depending on the type of paper being produced and the market price of recovered fiber, the cost of recovered paper can make up 20-40% of the total cost of producing 100% recycled paper. For mills that use recovered paper, the cost of fiber as a portion of total production costs rose significantly with the mid-1995 increase in recovered paper prices. Prices for finished paper products have also risen, for recycled paper producers more than fully offsetting the increase in recovered paper prices, and for virgin paper producers providing the substantial operating profit margins typical of the upside of the paper-pricing cycle.

With 534 pulp and paper mills operating in the United States in 1994, the comparative cost of manufacturing virgin and recycled paper depends on a number of factors, including the amount of recycled fiber in the sheet, the cost of recovered paper (the raw material), the grade of paper being produced and the configuration and age of individual mills. Some mills make 100% recycled-paper products, some make only virgin paper products and some blend virgin and recycled fiber. Non-integrated mills (those that do not have their own virgin pulp manufacturing systems) typically can use either virgin or deinked pulp purchased on the market.

For integrated pulp and paper mills, as a general rule, the economics of adding a recovered-fiber cleaning and processing system are most attractive when the mill is undergoing an expansion or renovation and needs more pulp. Recovered-fiber processing systems achieve economic scale at 200-400 tons per day of production, compared to 1,000-1,400 tons per day for new virgin kraft pulp mills. When existing virgin pulping systems cannot be economically expanded, the smaller recycling systems offer a better fit with incremental expansions of papermaking capacity. They can also be permitted and built more rapidly.

The use of recovered fiber in manufacturing corrugated boxes, paperboard for folding cartons, newsprint and tissue products used in the commercial ("away from home") market and the "value" sector of the residential market is well-established. As mills making these grades of paper have expanded over the last two decades, many have installed recovered-fiber processing systems. When prices for recovered paper are within their historical price range, the average mill making recycled paper in these grades has a lower cost structure than the average mill making the same grade of virgin paper.[39]

Office papers and other white papers have long been collected for recycling into tissue and paperboard products. The recycling of white paper used in offices back into printing and writing papers is a new phenomenon, partly because the deinking technology that can achieve this result has been in use in the United States only since about 1989. As a result, fewer printing and writing paper mills have had the opportunity to install deinking systems as part of capacity expansions that naturally occur over time. This has led many producers of printing and writing paper to charge a price premium for recycled content, as discussed in more detail on page 91.

In order to understand the impact of recovered paper prices on the comparative cost of making different grades of virgin and recycled paper, the Task Force conducted a sensitivity analysis using low, high and projected "trend" prices for recovered paper.[40] Trend prices are comparable to a long-term average, above and below which prices may fall at any given time.[41] The results of this analysis are provided in the sections on specific grades of paper in this chapter and in more detail in White Paper No. 9. The analysis shows that *for many paper grades, including most types of printing and writing papers, the projected "trend" price range for recovered paper will provide a good economic incentive to support the collection of paper for recycling and also a raw material cost that is competitive with virgin fiber for paper manufacturers.* This situation will certainly not apply to every paper mill, but when recovered paper prices are at projected trend levels, there will be a set of paper manufacturers that can manufacture large quantities of high-quality recycled-content paper products at costs competitive with virgin producers.

3. Projections of the future cost of pulpwood

The cost of pulpwood also affects the relative cost of manufacturing paper using virgin and recycled fiber. Resource Information Systems, Inc. (RISI), a forecasting and economics consulting firm that specializes in forest products and paper, projects that pulpwood prices in the United States will rise significantly between 1994 and 2000. According to RISI, "southern pulpwood prices began rising in real terms around 1989, have already recouped all of the declines that occurred in the 1980's, and are starting to recoup the declines registered in the 1970's. By next year [1996], real pulpwood prices in the South will have broken a 30-year record high in real terms, and will be heading up substantially from there. The overwhelming factor is that harvesting is now exceeding growth in the South for softwood fiber, and inventories of standing timber are declining." According to RISI, inflation-adjusted average prices for southern hardwood and softwood chips will increase 33% and 34%, respectively, between 1994 and 2000.[42]

Forest products companies interviewed by the Paper Task Force also project that prices for hardwood fiber used in papermaking will increase in real terms by the end of the decade. This is significant for recycling because deinked pulp made from recovered office paper is primarily a substitute for bleached kraft hardwood pulp when it is used in printing and writing papers.

A different forecast is provided in an earlier report by the U.S. Forest Service. Relative to 1991, the Forest Service projects an actual modest decrease in real softwood and hardwood pulpwood prices in the year 2000 in all U.S. regions except for softwood in the North.[43] One difference between the RISI and U.S. Forest Service pulpwood price estimates is the assumed rate of increase in demand for engineered wood products, such as oriented strand board (OSB). Engineered wood products are made from the same types of plantation-grown pine trees that typically are chipped and pulped to make paper in the South, and thus compete for this source of wood. RISI projects that such products will gain a much larger share of the structural lumber market than does the Forest Service.

The Forest Service also attributes much of the stability in its projected pulpwood prices to the role that increased recovery of paper plays in extending the fiber supply. The increased supply of fiber created by expanded paper recycling is seen to have a moderating effect on pulpwood prices. Both forecasts conclude that recycling will play an important economic role in the overall market for fiber used in making paper in the United States.

4. Increased recycling as a cost-containment strategy for paper purchasers

A key conclusion from the Paper Task Force's research is that increased paper recycling has the potential to change the dynamics of markets for new paper products in a way that reduces paper prices.

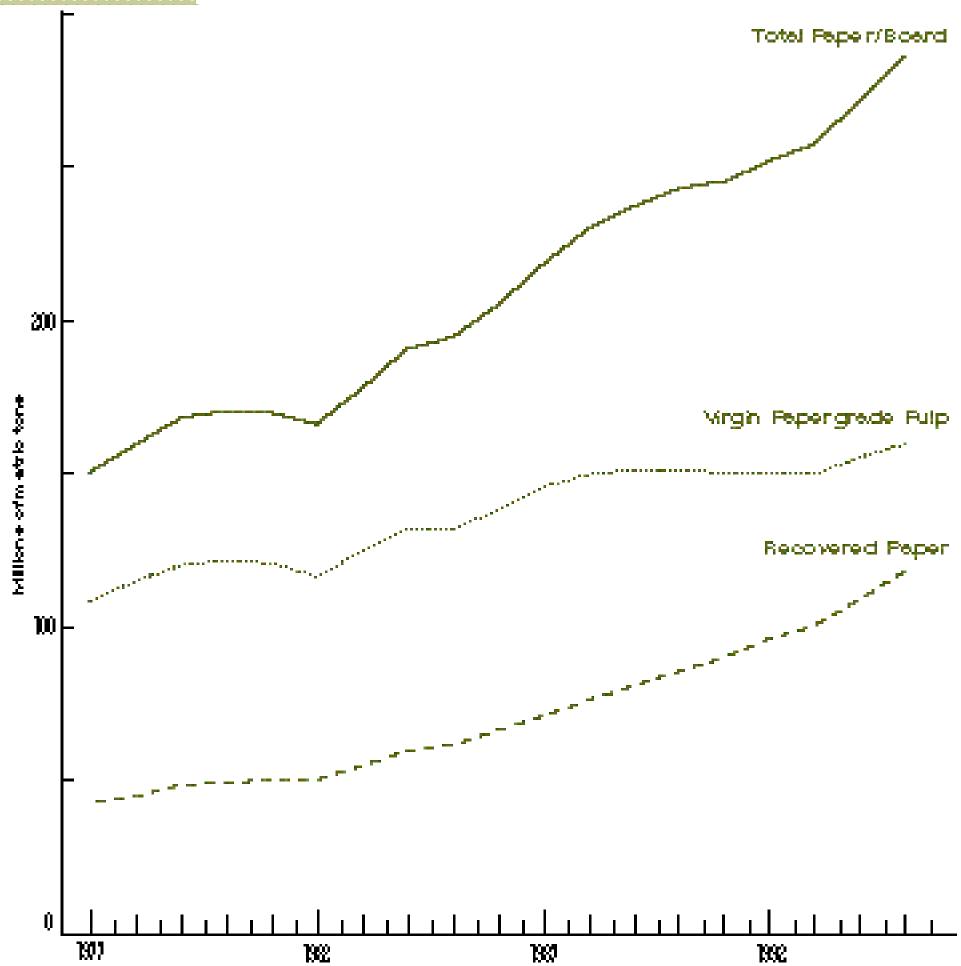
Paper prices in the short term are determined by supply and demand factors. In the long term, manufacturing costs also play a role. Above-average profit margins for a particular product tend to draw new manufacturers into the field and lead existing producers to expand capacity. Conversely, if market prices are below manufacturing costs over a significant period of time, affected mills will either shut down, go bankrupt and reemerge with lower costs, or renovate and shift to making different grades.

As of mid-1995, paper prices were reaching all-time highs, reflecting a peak in the demand for paper relative to available supply, as has occurred in past pricing cycles. This time around, however, there are three new factors in the equation, all of which suggest that the upside of the paper pricing cycle may be sustained differently than in the past. First, in the United States, there are relatively few major expansions in paper-manufacturing capacity announced or under construction, especially in printing and writing grades. Second, inflation-adjusted U.S. prices for raw materials used to make paper — pulpwood, virgin market pulp and recovered paper — have climbed above their historic highs, with further significant increases in pulpwood prices expected by the end of the decade.

Third, increases in both total and per-capita demand for pulp and paper, both in the United States and worldwide, are also projected for the medium term. Growth in demand relative to local supply will be particularly acute in Asia, which will be the largest net importing region in the world. Demand for paper in Asia is projected to grow to 107 million tons by the year 2000, compared to 60.3 million tons in 1990. "The fast growth in consumption will outpace even the large amount of investment in new capacity in the region, requiring an increasing amount of imported paper products."[44] Some analysts predict that the growth in demand in Asia will be partially supplied by pulpwood producers in the southern United States, given its

Figure 5

World Production of Paper and Paperboard, Total Papergrade Pulp Production and Recovered Paper Consumption



Source: Resource Information Systems, Inc., 1995

relative production costs and the largely open market situation that prevails, especially for non-industrial private owners.[45]

Seeking to bring the supply and demand (and therefore pricing) for paper back into balance, paper users themselves cannot build new mills or plant and harvest additional trees. They can influence the supply of fiber, however, by increasing the collection of used paper for recycling. They can influence market demand by expressing a preference for paper with recycled content. If taken by many paper users, these two actions will create incentives for paper manufacturers to expand recycling-based paper production capacity.

The recent history of paper recycling underscores the power of this approach. Growth in recycling-based paper manufacturing capacity is now outpacing growth in virgin paper production capacity. Between 1984 and 1994, U.S. production of pulp from wood grew by 10.2 million tons, while consumption of recovered paper by U.S. paper manufacturers grew by 13.3 million tons.[46]

The case of linerboard and corrugating medium used to make corrugated boxes provides an example of the market impact that recycling can have. Between 1990 and 1995, total U.S. corrugated containerboard capacity is projected to grow from 28.4 to 33.0 million tons per year, or 16%. Of the 4.6 million tons of containerboard capacity growth, 3.0 million tons will be made from 100% recycled fiber and an additional increment will be a recycled/virgin fiber mix.[47] When the costs to mills of using old corrugated containers and mixed paper are within their historical range, capital and operating costs are generally lower for recycling-based expansions compared to new virgin containerboard capacity. According to *Pulp & Paper Week*, the new containerboard capacity is moderating potential price increases.[48] Recycling has also played a key role in supporting the expansion of low-cost manufacturing capacity in the commercial and institutional segment of the tissue industry over the last 15 years.[49]

A similar case could be made that deinked market pulp is affecting prices for its functional competition, virgin hardwood market pulp, in comparison to virgin softwood market pulp.[50] Deinked market pulp now makes up roughly 10% of U.S. market pulp production. Increased BCTMP pulp and Indonesian hardwood market pulp also affect the global hardwood pulp pricing equation, however.

5. The economic benefits of increased recycling for paper producers

Increased collection of paper for recycling can also benefit paper manufacturers. An increased supply of recovered paper will help keep the cost of recovered paper at a level that maintains the comparative manufacturing cost advantage for grades of paper that have traditionally contained recycled content. Paper manufacturers considering incremental increases in capacity that could be supplied by recovered-fiber processing systems will be more likely to make these investments. The Task Force has interviewed several manufacturers who were considering such expansions and who put their plans on hold when recovered-paper prices rose sharply in early 1995. Increased recycling will also help moderate the long-term effect of increasing pulpwood costs on overall prices for new paper.

An econometric study conducted at the U.S. Forest Products Lab shows that, by extending the fiber base, higher recycling rates will allow greater overall industry growth than low recycling rates. According to the study, "increased paper recycling will extend U.S. fiber resources and contribute to enhanced competitiveness for the U.S. pulp and paper industry (and will also extend timber resources for the lumber and plywood sectors). Increased export and decreased import of pulp, paper and paperboard products will significantly improve the U.S. balance of trade."[51]

The power of recycling to allow judicious use of wood resources is greatest when viewed on a global scale. In 1994, approximately 20% of all paper produced *worldwide* was discarded into municipal solid waste in the United States.[52] An increase in the collection of paper for recycling in the United States from 40% to 50% would equate to a 3.3% increase in fiber supply worldwide.[53] As shown in Figure 5, global demand for paper has been growing significantly faster than production of virgin wood pulp used in making paper, and recycled fiber has been filling the gap. From 1985 to 1995, worldwide paper and paperboard production grew by an estimated 90 million tons, recovered paper consumption grew by 55 million tons, and wood pulp production grew by 27 million tons.[54] In parts of the world that do not have major forest reserves, such as regions within Asia and Europe, individual paper fibers are recycled more than once. In these situations, one ton of recycled fiber used multiple times is actually substituting for several tons of wood pulp.

V. FINDINGS FOR SPECIFIC GRADES OF PAPER

Printing and Writing Paper

Printing and writing paper, used in myriad products such as books, magazines, business communications and advertising, is probably the type of paper most people encounter most often in their daily lives. Printing and writing paper is the largest category of paper used in the United States; 25.7 million tons were manufactured domestically in 1994, and another 3.7 million tons were imported (net), in total making up about one-third of all U.S. paper shipments.[55] Of all the major paper grades, printing and writing paper generally has the highest value, both as new paper and as a used material collected for recycling.

Ton for ton, replacing virgin kraft pulp with deinked pulp will have the greatest positive environmental impact on forest resources.

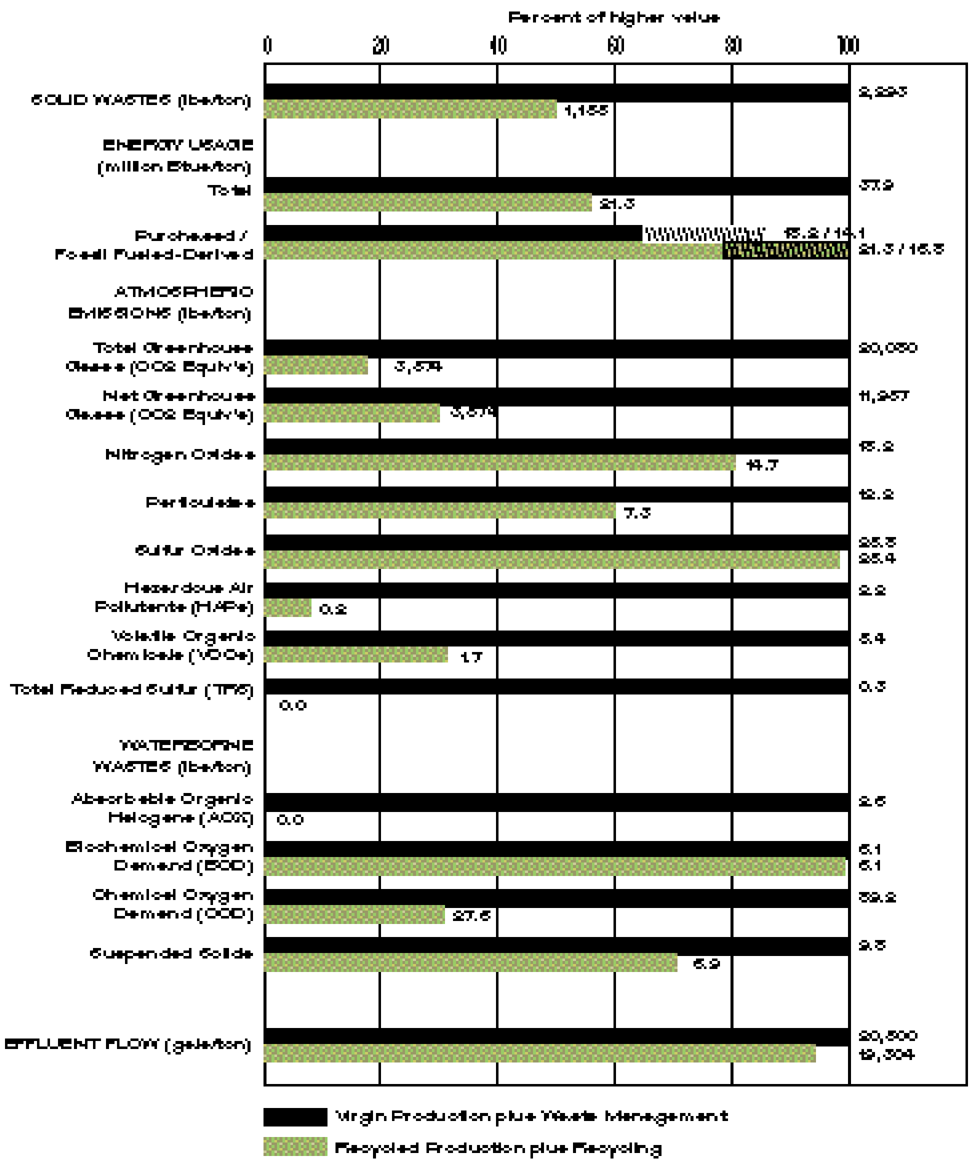
1. Environmental issues

The lifecycle comparison of virgin and recycled office paper systems developed by the Task Force examined a total of 16 parameters, including total and purchased energy, eight categories of pollutant releases to air and four to water, and quantities of effluent and solid waste. *Ton-for-ton, 100% recycled paper made from deinked used office paper is preferable (for most parameters) or comparable (for three parameters) to 100% virgin paper.* The only exceptions are purchased and fossil fuel-derived energy, where the recycled system exceeds the virgin system by 17% and 19%, respectively. Figure 6 shows this comparison. For a paper sheet that contains a blend of virgin and recycled pulp, the environmental profile would be intermediate to that described here and proportional to the relative amounts of virgin and recycled pulps.

Deinking mills use somewhat larger amounts of purchased energy compared to virgin bleached kraft pulp mills, but considerably less total energy. When all of the activities that comprise the virgin and recycled lifecycle systems are factored in, the recycled

Figure 6–Office Paper

Average Energy Use and Environmental Releases for Managing Office Paper by Recycled Production + Recycling vs. Virgin Production + Waste Management (Landfilling and Incineration)*



fiber-based system still uses more purchased energy and much less total energy than the virgin fiber-based system.

Finally, virgin printing and writing papers (specifically uncoated freesheet, coated freesheet and the kraft portion of coated groundwood papers) require the most wood of the paper grades studied by the Task Force, about 3.5 tons of trees (assuming 50% moisture content) to produce a ton of paper. This is due to the average 45% yield associated with kraft pulping and bleaching.[56] Hence, ton for ton, replacing virgin kraft pulp with deinked pulp will have the greatest positive environmental impact on forest resources.

2. Availability

The addition of recycled content to printing and writing paper is a relatively new phenomenon, in part because deinking technology has improved substantially since the mid-1980's. In 1989, recovered paper made up less than 6% of the fiber used in printing and writing paper, almost all of which came from preconsumer sources.[57] In contrast, between 1993 and 1997, the majority of newly constructed pulping capacity oriented toward printing and writing paper will use recycled rather than virgin fiber. By 1997, capacity will exist in the United States to make approximately 3 million tons of deinked pulp of a high enough quality for use in printing and writing papers.[58] Since deinked pulp is usually blended with virgin fiber in the manufacture of printing and writing papers, this means that substantial quantities of printing and writing paper with recycled content will be available in almost all grades.

Four large U.S. mills with integrated or semi-integrated deinking capacity will produce 1.6 - 1.8 million tons per year of paper with 20-35% postconsumer recycled content by 1996, in addition to at least one large Canadian producer. Fourteen small or medium-sized mills with their own deinking plants will also be producing coated and uncoated printing and writing paper products by this time, compared to eight in 1989.

3. Paper performance

Manufacturers and users of both recycled-content and virgin paper assess performance in two ways: by means of individual physical specifications (for example, moisture content, opacity, brightness, smoothness) and actual performance in printing presses and office equipment. The Paper Task Force's research shows that, by these standards, there are commodity grade papers available today containing postconsumer recycled content that meet customers' requirements for runability and print quality.

Uncoated freesheet papers with 10-35% postconsumer content are currently available that meet the functional requirements of office users and consistently perform well in low-, medium- and high-speed copy machines, fax machines and laser-jet printers and offset presses. Papers with 50-70% postconsumer content are available on a more limited basis. There are specialty-grade business papers and publication papers that contain from 20% to 100% postconsumer content and meet functional requirements. Based on extensive interviews with paper and equipment manufacturers, the Task Force found that frequency of copy machine jams is not correlated with the use of recycled-content paper.[59] The majority of jams are a function of several factors, such as two-sided copying, the speed and condition of equipment, the quality of the paper being used (whether recycled or virgin) and operator errors.

Lightweight coated papers with 10-15% postconsumer content, medium and higher-weight coated papers with 10-30% postconsumer content and uncoated groundwood publication papers with 10-60% postconsumer content are available that meet the functional requirements of users and consistently perform well in offset printing presses and finishing operations. In the paper-manufacturing process, it is more challenging to use deinked fiber in coated papers because of the sensitivity of the coating process to contaminants on the surface of the paper sheet.

The experience of several large publishers, printers and paper manufacturers confirms that acquiring a level of familiarity with the paper, whether virgin or recycled-content, prior to printing a job is a key to successful printing. Press adjustments (for example, press speed, roller tension, composition of the fountain solution/inks) required to accommodate the characteristics of recycled-content paper are analogous to what is required for any change in paper stock, including virgin grades. For books, recycled-content paper can have better dimensional stability and increased bulk compared to virgin paper. These properties help the paper lay flat and improve the "feel" of book papers, respectively.

Brightness specifications for most business papers and publication papers can be met when using recycled content at the levels described above. Recycled-content business papers with 10-35% postconsumer content are available with brightness levels of up to 89 GE brightness (see the Explanation of Key Terms and Abbreviations for a description of how brightness is measured). There are few high-brightness (above 90) uncoated freesheet papers available with postconsumer content. However, less than 10% of the uncoated freesheet market is comprised of high-brightness papers.

Manufacturers produce coated freesheet grades with 10-15% postconsumer content that meet typical brightness specifications for magazines, trade books and textbooks. However, it is more difficult to reach the high-brightness levels specified for some coated freesheet grades with recycled content.

4. Price premiums for printing and writing paper with recycled content

A major concern to purchasers is whether or not printing and writing paper with recycled content will cost more than virgin paper. Evaluating this issue requires an understanding of market dynamics and manufacturing costs, which are discussed in this section and the two sections that follow.

In general, producers have the ability to set price premiums under a variety of different conditions. For example, sellers may obtain a premium when a new product is introduced that has special features that add value for customers. Manufacturers who face higher production costs for new products may seek price premiums to justify their additional expenditures compared to their standard production runs. Premiums are also likely when there is limited competition among sellers or when demand is significantly greater than supply. In this case, limited supplies are allocated among potential customers based on their willingness to pay higher prices. In 1995, many of these factors were at work in the market for recycled-content printing and writing paper.

Due to the high cost of recovered paper and high overall demand for finished paper, as of mid-1995 many producers of printing and writing papers were asking their customers to pay a price premium for paper with recycled content. The premium is generally on the order of 5-10%, and comes on top of major increases in the price of paper overall. The level of the premium depends on the manufacturer and the market, and is not always present, especially at the retail level.

In a time of high prices for new paper products, manufacturers of virgin and recycled paper are both achieving positive returns; this is certainly the case at recycled content levels of 10-30%. Charging a premium is required to maintain the same profit margin in making recycled-content paper as a mill is achieving with virgin paper.[60] In contrast, price premiums are generally not being charged for tissue, paperboard and newsprint with recycled content, for several reasons.[61]

Purchasers should be aware of several factors that may serve to reduce price premiums over time, or that could have the opposite effect. Paper purchasers and users, in the aggregate, can influence many of these factors themselves. For example, greater collection of recovered paper for recycling will tend to reduce manufacturers' cost of using recovered paper. Paper use reduction steps like those outlined in Chapter 2 can ease tight market conditions.

As paper demand and supply come into greater balance, large mills with integrated deinking plants may reduce price premiums and use recycled content as a competitive tool to retain market share, compete more effectively for the best customers, and keep their mills running at full capacity. Increasing prices for pulpwood, particularly hardwoods, may bring the cost of producing virgin and deinked pulp closer together. On the other hand, high prices for recovered paper and a very tight market for new paper would maintain pressure to preserve price premiums. By assessing factors such as these, purchasers should be able to gauge whether or not price premiums are justified for specific grades of paper.

5. The cost of producing printing and writing paper with recycled content

Paper mill operators who want to produce printing and writing paper with recycled content face a "make vs. buy" decision. They can either install their own deinking systems or purchase deinked market pulp from another producer. *Integrated deinking plants* are located adjacent to paper mills, which may also make or buy virgin pulp to supply their paper machines. Independent *deinked market pulp* (DMP) mills purchase recovered paper, remove the ink and other contaminants, and sell the pulp to a paper mill for use on existing paper machines. Given these options, the costs of producing printing and writing paper with recycled content depend on how the deinked pulp is produced, the configuration of the paper mills that use it and the comparative cost of using recovered paper versus virgin pulpwood.

The cost of producing deinked pulp

Approximately 70% of deinking capacity for producing printing and writing paper grades to be constructed from 1989 to 1997 will be at deinked market pulp facilities. By the end of 1997, there will be at least 20 deinked market pulp mills operating in the United States making a pulp of sufficient quality for use in printing and writing paper; in 1989, there were four.[62]

Overall, deinked market pulp mills provide a more flexible but slightly more expensive means of furnishing recovered fiber pulp to paper mills than do integrated deinking mills. Purchasing deinked market pulp does not require a major capital investment by paper manufacturers; the investment is made by the company producing the pulp and its financial supporters. Smaller paper mills that could not use all the pulp from a full-scale deinking plant can buy DMP in amounts that meet their needs. Paper manufacturers can use DMP to make different quantities of paper with varying levels of recycled content to meet market demand. On the other hand, producing DMP generally costs more than making deinked pulp at integrated mills, in part due to pulp drying and transportation costs.

By September 1995, competition between deinked market pulp manufacturers, falling prices for recovered office paper and rising prices for virgin market pulp forced the price of DMP below that of bleached kraft hardwood pulp for the first time ever, in a highly unsettled market.[63] This is especially important for non-integrated or semi-integrated paper mills that have a choice in buying market pulp.

If deinked market pulp costs more to produce than integrated deinked pulp, both generally cost more to manufacture than virgin bleached hardwood kraft pulp, even at projected trend prices for recovered paper. Very high prices for recovered fiber, such as those prevailing in mid-1995, heighten this difference. However, there will be some overlap in production costs for specific mills. Low-cost recycled pulp producers may be more than competitive with high-cost virgin pulp producers.[64]

The cost of pulp is only one factor that determines the total cost of making paper. Other aspects of paper mill configurations that influence the cost of making recycled paper are described in the next section.

6. Manufacturing costs for specific paper grades

a) Commodity uncoated freesheet

"Commodity uncoated freesheet" refers to paper grades used in photocopy machines, computer printers, business forms, envelopes and long offset printing runs. These papers are produced in large volumes at integrated virgin pulp and paper mills.

The comparative cost of using deinked pulp to make commodity-grade uncoated freesheet with recycled content depends on the grade of paper, the level of recycled content, the configuration of the individual mill and the cost of purchasing recovered paper or deinked market pulp. Different cost scenarios are presented in the text box below.[65] Mills in the United States can be found in all of the different scenarios outlined here. This in part accounts for the variability in availability and pricing for different brands of printing and writing paper with recycled content.

b) Specialty uncoated freesheet papers

In contrast to commodity-grade papers, the paper industry produces a number of paper products in smaller quantities, usually at small- to medium-sized mills, that tend to sell for higher prices. For the sake of simplicity, we will refer to these grades as "specialty" papers.[71] One example of this type of paper is text and cover papers used in books and reports. These papers are also used in highly visible, customer-oriented products that tend to have short printing runs and place a greater importance on the appearance and "feel" of the paper. Such uses include brochures, invitations, stationery, business cards, menus, etc. For a variety of reasons, recycled content may be an important aspect of the presentation made by these paper products.

Compared to commodity-grade printing and writing papers, high-value papers with recycled content are less likely to carry a price premium for recycled content, and when they do, the premium is usually a lower percentage of the selling price. This is true for several reasons.

Some text and cover paper mills have been producing paper with recycled content for several decades. These mills have modernized their deinking facilities in order to handle postconsumer recovered paper, but at least part of their deinking systems may be more fully depreciated than the brand new deinking plants being installed at commodity printing and writing paper mills. Investments in deinking at these mills are sunk, compared to discretionary purchases of deinked market pulp at other mills.

Many specialty printing and writing paper mills are non-integrated or semi-integrated to virgin pulp production. These mills purchase market pulp to obtain fiber for making paper. They directly compare the price of purchasing virgin and deinked market pulp. Between 1989 and 1995, the price of deinked market pulp was higher than virgin market pulp; in the fall of 1995 this position was reversed. Smaller non-integrated mills are likely to operate at less-than-full capacity utilization, especially during the downside of the paper-pricing cycle. If it helps a mill sell more paper, adding recycled content may improve the overall economics of running the mill due to declining marginal costs of production.

> By the end of 1997, there will be at least 20 deinked market pulp mills operating in the United States making a pulp of sufficient quality for use in printing and writing paper; in 1989, there were four.

Even when purchasing deinked market pulp is more expensive than purchasing virgin market pulp, the manufacturing cost impact as a percentage of the total selling price will be less. This is simply because text and cover paper tends to sell for roughly twice the price of commodity uncoated freesheet paper.

c) Coated freesheet papers

The large number of uncoated freesheet mills operating in North America means that there have been more opportunities over time for these facilities to add deinking systems as they undergo incremental expansions. In comparison, there are a smaller number of mills making coated freesheet, so that opportunities for adding integrated deinking facilities have been comparatively limited. As of 1995, two relatively small coated freesheet mills in the United States operated their own deinking plants[72]. A number of other mills purchased DMP to make paper with recycled content.

Manufacturing cost scenarios for adding postconsumer recycled content at coated and uncoated freesheet mills

These scenarios start with the lower-cost manufacturing cases and end with the highest.

Mills that have some existing recycling equipment

Several small- to medium-sized U.S. paper mills now making paper with recycled content were able to install deinking systems at a low capital cost compared to completely new systems. These mills already had some equipment on site that could be adapted to create a viable deinking plant. Other recycling-based mills have upgraded their deinking systems to handle postconsumer recovered paper.[66] Most of these mills are not integrated to virgin pulping systems.

Integrated mills undergoing incremental expansions of paper production capacity

Mills typically expand their capacity to make paper by increasing the running speed of existing paper machines or by installing a new machine. *When recycling systems are considered for such mills, the cost of producing deinked market pulp is evaluated as part of the overall expansion package.* When virgin pulp mills have reached their production limits and cannot be incrementally expanded in a cost-effective manner, a deinking plant may be the most economical means of gaining a 200-400 ton per day increment of pulp production. One large southern printing and writing paper mill started up a 300 ton-per-day deinking plant in late 1994, which will eventually support a 300 ton-per-day expansion in paper production at the same mill.[67] Modular deinking systems based on technology used in washing industrial textiles are now being developed and sold. If successful, these systems could be installed as single units producing 100 tons of deinked pulp per day at per-ton costs comparable to larger deinking systems.[68]

Mills with extra pulp drying capacity

Some mills make both virgin market pulp and paper and have extra pulp drying capacity available. Such mills could add a deinking system and make market pulp or paper with varying levels of recycled content depending on market conditions. With a pulp-drying machine already in place and operating, the incremental cost of drying additional tons of pulp is relatively low. The economic picture is similar to the case above, but there is more exposure to the profit and loss potential of the virgin and deinked pulp market. These mills could also add a very large new paper machine and use the deinked pulp to supply part of the new machine's pulp requirement. Two large, integrated southern mills in this configuration started deinking plants of 234 and 400 tons per day of production in 1995; both are also in the process of adding world-class paper machines.[69]

Mills with a minor increment of paper machine capacity available

Some mills have production capacity available on their paper machines that is slightly greater than their overall production of virgin pulp. This situation occurs because it is often easier for mills to speed up their paper machines than to gain increments of virgin pulp production capacity. These mills might not be candidates for installing their own deinking systems, but could buy deinked market pulp to add to some of their production. In this case, they would compare the cost of deinked market pulp to the cost of virgin market pulp. The per-ton cost of paper production declines as a machine is brought up to full capacity, because fixed and semi-variable costs are allocated over greater quantities of production.

Mills that are closely balanced in virgin pulp and paper production

The increase in costs associated with buying deinked market pulp would be greatest for mills that are closely balanced in their virgin pulp and paper production and do not have pulp drying capacity available. In calculating their manufacturing costs, they would compare the cost of buying deinked market pulp to the "cash cost" (variable cost) of making their own virgin pulp. Buying deinked pulp will invariably be more expensive in this comparison, because the capital costs of the virgin pulp system are sunk and are not counted. In addition, virgin pulp production may have to be curtailed to allow for the use of DMP, which would increase the average per-ton cost of making virgin pulp. Such mills are not good economic candidates for adding recycled content to their paper.[70]

The economics of adding DMP to coated freesheet are similar to the economics of adding DMP to uncoated freesheet, as are the economics of installing integrated deinking systems. In both cases, DMP is essentially a substitute for virgin hardwood pulp. The key cost factors include whether or not the mill has extra papermaking capacity beyond its virgin pulp capacity and, if this is the case, the comparative cost of virgin and deinked market pulp.

As a percentage of the selling price of paper, the cost of adding DMP to coated freesheet is smaller than commodity uncoated freesheet, because coated freesheet sells for a higher price. In addition, meeting a 15% level of recycled content, for example, actually requires less recycled fiber per ton for coated than uncoated paper, because the recycled content is most often measured as a percentage of the fiber weight in the paper sheet, and coated paper is made up of only about two-thirds fiber. Nonetheless, due to the cost of using deinked market pulp compared to producing virgin bleached kraft pulp, most coated freesheet available with recycled content in 1995 is selling at a price premium.

Two coated paper manufacturers now own deinked market pulp mills, one of which is essentially integrated to the paper mill. These mills both produce coated groundwood and freesheet papers, but the majority of the deinked pulp that they consume is used in freesheet grades.[73]

d) Coated groundwood papers

At comparable percentages of recycled fiber content, the cost impact of adding recycled fiber is usually greater for coated groundwood papers than for coated or uncoated freesheet papers. Lightweight coated papers contain a mix of bleached softwood kraft and mechanical pulp. Deinked market pulp is typically used to replace these two types of virgin pulp on a 50/50 basis, in order to maintain the strength and opacity of the paper.

Deinked market pulp produced from office papers is essentially a bleached hardwood kraft pulp substitute. The cost of purchasing deinked market pulp is substantially greater than the cost of manufacturing virgin mechanical pulp. Deinking of used newspapers and magazines (which contain mechanical pulp themselves) may be a more economical means of making groundwood-containing printing and writing paper with recycled content. Actual operating experience with this approach in the United States and Europe is limited.[74] A major U.S. producer announced in October 1995 that it is considering partially converting a large newsprint mill to lightweight coated groundwood paper at a site with a large deinking plant that uses old newspapers and magazines.[75]

Corrugated Boxes

Corrugated shipping containers play a major role in distribution of products in the United States. Strength is their most important performance attribute but is not the only feature that may be important to purchasers. Corrugated boxes are made from a combination of linerboard and corrugating medium, which in this report we call “containerboard.”[76] Containerboard is one of the largest uses of paper used in the United States, with a production of 28.1 million tons for domestic use in 1994, including 19.3 million tons of linerboard and 8.8 million tons of corrugating medium.[77]

In sum, purchasers can buy corrugated boxes that reduce environmental impacts in at least four ways, usually saving money or maintaining price parity:

- Boxes are available with *recycled content*
- They can also have *reduced basis weight*
- They can be designed for *source reduction*
- The use of film laminates, the “bag-in-box concept” and new water-resistant coatings can potentially help make wax-coated boxes *more recyclable*

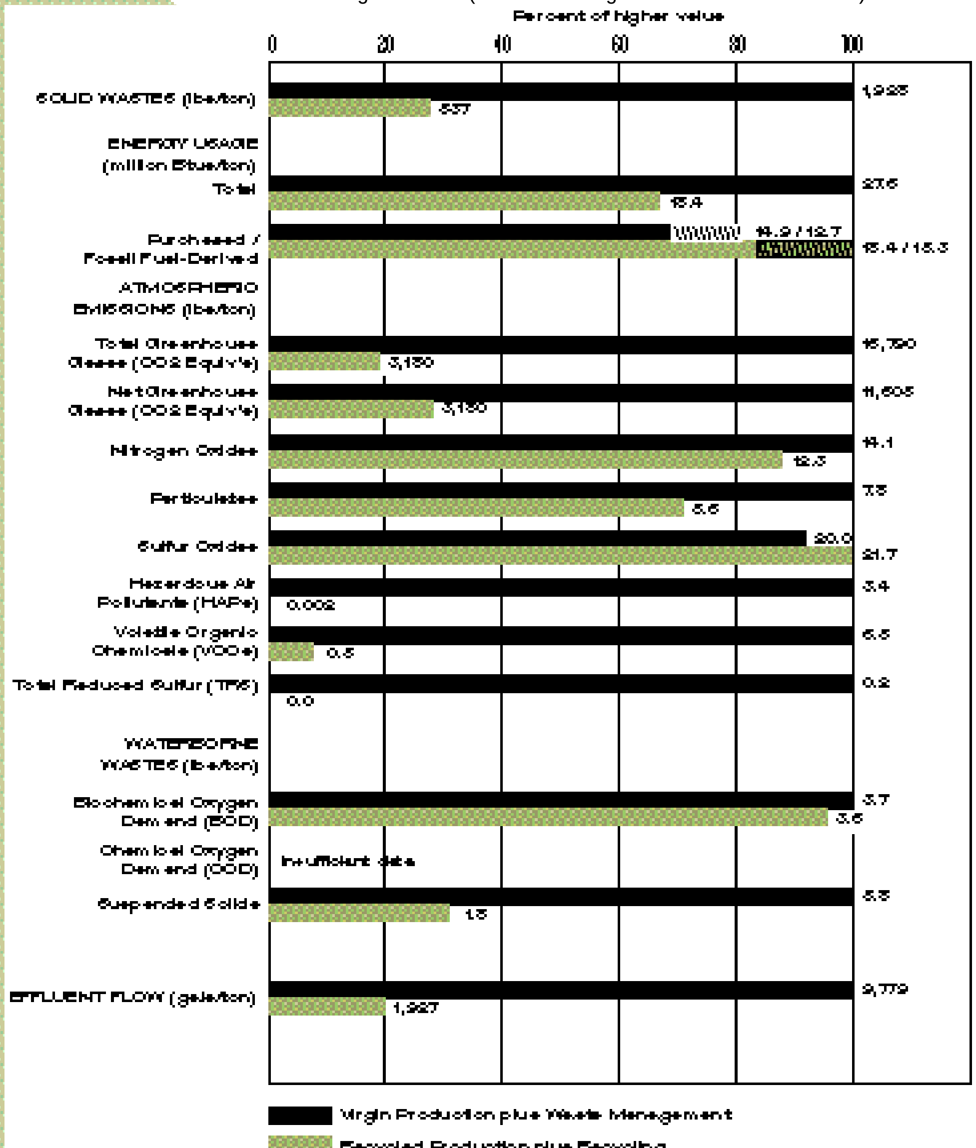
All of these steps can be taken without compromising the performance of the container.

1. Environmental issues

The lifecycle comparison of virgin and recycled corrugated box systems developed by the Task Force examined a total of 14 parameters, including total and purchased energy, eight categories of pollutant releases to air and three to water, and quantities of effluent and solid waste. ***Ton-for-ton, 100% recycled containerboard made from old corrugated containers is preferable (for most parameters) or comparable (for two parameters) to 100% virgin containerboard. The only exceptions are purchased and fossil fuel-derived energy, where the recycled system***

Figure 7–Corrugated Boxes

Average Energy Use and Environmental Releases for Managing Corrugated by Recycled Production + Recycling vs. Virgin Production + Waste Management (Landfilling and Incineration)*



*assumes the national proportion of waste (after recycling) managed by landfilling (79.7%) and incineration (20.3%)

exceeds the virgin system by 23%. Figure 7 shows this comparison. For a corrugated box that contains a blend of virgin and recycled pulp, the environmental profile would be intermediate to that described here and proportional to the relative amounts of virgin and recycled pulps.

Containerboard recycling mills use somewhat larger amounts of purchased energy compared to virgin unbleached kraft pulp mills, but considerably less total energy. When all of the activities that comprise the virgin and recycled lifecycle systems are factored in, the recycled fiber-based system still uses more purchased energy and less total energy than the virgin fiber-based system.

Mills using recovered corrugated containers produce comparable or slightly higher amounts of solid waste compared to virgin corrugated mills, due in large part to higher rates of sludge generation. However, when the amount of waste avoided by reutilizing most of the fiber in the recovered material is considered, the recycled fiber-based system results in about one-quarter as much solid waste as the virgin fiber-based system.

Finally, virgin corrugated containerboard requires almost three tons of trees (at 50% moisture content) to produce one ton of containerboard. This is due to the average 57% yield associated with unbleached kraft pulping and the low percentage of fillers used in linerboard and medium.[78] Replacing virgin unbleached kraft and semichemical pulps with pulp made from recovered corrugated will reduce considerably the number of trees needed to make this grade of paper, with concomitant positive impacts on forest resources.

2. Availability

Recycled content levels historically have been relatively high in the containerboard industry and have been growing in recent years. Of the 55 mills producing linerboard in the United States, 14 currently use 100% recycled fibers as a furnish, 34 use a mix of recycled and virgin fiber, and 7 use 100% virgin fiber. Of the 60 corrugating medium mills in the United States, all use some recycled fiber and 33 use 100% recycled fiber.[79]

The majority of incremental expansions and new machines added to make linerboard and corrugating medium since the mid-1980's have been based on recovered fiber. Between 1994 and 1997, more than 5 million tons of new capacity to produce recycled linerboard and corrugating medium will come on-line. Approximately 42 of the 54 new mills, major expansions or incremental increases in containerboard capacity to be built during this period are based on 100% recycled fiber.[80]

Linerboard mills have traditionally used clippings from box plants as a source of fiber, and old corrugated containers (OCC) have been a major source of fiber for corrugating medium. The trend toward more widespread use of postconsumer recycled content in containerboard began for the most part in the early 1980's, supported by several factors. Improvements in paper mill headbox, press section and drying technology have made it possible to compensate in the manufacturing process for some of the lower-strength properties of recovered fiber. Improvements in OCC screening and cleaning technology have also facilitated the utilization of more recovered fiber.

These technologies have not only improved the quality of containerboard made from recovered fiber, but have also allowed mills to incrementally expand their paper production, requiring an increased supply of pulp. Installing an OCC pulping and cleaning line is often the most economical way to provide increments of pulp below the scale of large virgin pulping systems. Finally, some customers are requesting boxes that contain recycled content.

Between 1990 and 1994, the average total recycled content for corrugated boxes increased from 26% to 38%.[81] The recovered fibers used are mainly postconsumer materials, although precise data on percentages are not available. The generation of preconsumer scrap through the box-converting process is estimated at 8% of total containerboard production, or the equivalent of 2.2 million tons in 1994; this scrap is used in the manufacturing of containerboard, 100% recycled paperboard and other products.[82] Average total recycled-content levels are higher for corrugating medium (59% in 1994) than for linerboard (25% in 1994).[83]

3. Performance

The ultimate performance of corrugated boxes, both recycled and virgin, depends as much on individual mill and converting technology as the type of fiber used. Recycled fibers from OCC are shorter and present some disadvantages in manufacturing compared to virgin unbleached kraft fibers. However, with new production technologies and adjustments in the papermaking process, manufacturers can produce boxes with high levels of recycled content and no loss in performance compared to boxes produced from virgin fibers. Based on these new technologies, some manufacturers produce corrugated boxes with 100% postconsumer recycled content with the same performance characteristics as virgin boxes.

Changes in freight carrier standards, primarily those used by the trucking and railroad industry, and the acceptance of compression-strength test standards, especially the Edge Crush Test (ECT), allow for both increased recycled content and source reduction through lightweighting. Recovered fibers were at a relative disadvantage under the old basis weight/burst strength test standards. With ECT as an alternative testing measure, recycled content can be increased and lighter-weight board can be used, with comparable performance to virgin boxes. The alternative testing measures have promoted the newly developed high-performance containerboard, which mainly includes lightweight containerboard with maintained edge-crush strength. Depending on mill technology, adding recycled content and reducing weight can be achieved simultaneously. A few manufacturers offer 100% recycled lightweight containerboard, for example.

4. Economics

It is generally less costly to make linerboard and corrugating medium using recovered fiber rather than virgin fiber, except when the cost of purchasing recovered paper is very high, as in mid-1995. This is especially true when incremental mill expansions are considered. When recovered paper costs are within their historical range, the more recovered fiber that is used in linerboard, generally the less expensive it is to manufacture.[84] This statement is based on cost estimates for average U.S. mills; there are variations at individual sites. Makers of corrugated boxes generally do not charge a price premium for recycled content.

The most recent development in recycled containerboard production is the "mini-mill." At 400 tons of production per day, these mills are small only in comparison with traditional large-scale virgin linerboard mills. Their size allows them to be built in more urbanized areas with reduced need for large water supply and wastewater treatment systems. One such mill has even been proposed for Staten Island in New York City.[85] Under projected "trend" costs for recovered paper, containerboard mini-mills generally have lower overall production costs than larger virgin and recycled linerboard mills.[86] The mini-mills obtain their cost advantages from lower transportation costs for recovered paper and finished product and from lower capital costs. A related trend is the conversion of old, small printing and writing paper mills to making 100% recycled containerboard.[87]

Given the high and volatile prices for OCC encountered in mid-1995, much of the attention of the industry is devoted to finding new sources of supply. The commercial sector accounted for 80% of OCC discarded (not recycled) in 1992.[88] Corrugated boxes are readily identifiable and bulky, making them comparatively easy to pull from mixed commercial waste on a tipping floor or conveyor. Increasing the recovery of OCC is therefore partly a matter of the incremental expansion of an already well-developed network.[89]

Much of the discussion in this area revolves around projections of the "practical recovery limit" for OCC and the potential to substitute mixed paper for 5-15% of the OCC furnish. The new generation of mini-mills may be able to make corrugating medium with up to 100% mixed paper.[90] The conclusion of officials who purchase recovered paper for major containerboard manufacturers and a number of studies on the topic is that the United States may be approaching a limit to the recovery of OCC, but has not reached it yet.

Different sources use different methods for defining the recovery of OCC. According to the Franklin Associates Ltd. consulting firm, 14.6 million tons, or 55.5% of all postconsumer OCC generated in the United States were recovered in 1993, and nearly 12 million tons were discarded.[91] The American Forest & Paper Association (AF&PA) includes both pre- and postconsumer recovered paper in its definition of OCC.[92] Using the AF&PA definition, 16.7 million tons of OCC, or 62.0% of a total containerboard production of 26.9 million tons, were recovered in 1993.[93] Using either method of calculating OCC recovery, large volumes are now being collected for recycling, but a significant tonnage is still being disposed.

Franklin Associates, AF&PA and other experts have concluded that there is sufficient available fiber that is currently not recycled to meet the current round of containerboard capacity expansions.[94] This fiber will come in part from OCC collected from small businesses and homes, and in part from mixed paper substituted for OCC.[95] Over the longer term, the interplay of market forces and recycling collection and fiber-processing technology will determine the ultimate limit on recycled content in corrugated boxes.

5. Purchasing corrugated boxes with environmental improvements

A range of options is available for purchasers of corrugated boxes that potentially offer environmental benefits: increasing source reduction, increasing recycled content and increasing the recyclability of coated boxes. Source reduction in corrugated packaging can also be facilitated by box redesign, an opportunity that is often overlooked. For example, boxes can be redesigned to optimize box size and maximize truck utilization, or the size of box flaps can be reduced.

It may be possible to increase the recyclability of waxed boxes through the substitution of repulpable coatings. Waxed boxes are mainly used in the meat, poultry and produce industries for water resistance. They constitute about 3-6% of all corrugated boxes produced, or 800,000 to 1.6 million tons of OCC. The wax is difficult to remove during repulping, causing problems in papermaking and affecting the quality of the new containerboard.

In order of their current availability, three alternatives to waxed boxes are possible: film laminates, the "bag-in-box" concept and repulpable water-resistant coatings. Boxes with laminated film linings are accepted by some containerboard manufacturers but not accepted by others. Plastic bags inside corrugated boxes should be removed prior to collection. The Fiber Box Association and the American Forest & Paper Association are working with containerboard manufacturers to set a voluntary industry standard for repulpable water-resistant coatings.[96]

Folding Cartons

Folding cartons are paperboard boxes that are creased and folded to form containers that are shipped and stored flat and erected at the point where they are filled. Designed to contain and present products to the customer, folding cartons are generally small enough to hold in one hand.[97]

The three major grades of paperboard used to make folding cartons are solid bleached sulfate (SBS), coated unbleached kraft (CUK) and clay-coated 100% recycled paperboard. Other terms for coated unbleached kraft paperboard include coated natural kraft and solid unbleached sulfate.[97]

In sum, environmental benefits, price and availability all weigh in favor of recycled paperboard. If limits arise in the use of recycled paperboard for a specific type of folding carton, they are likely to be related to performance issues. In these cases, adding recycled content to SBS or CUK may offer a comparative environmental advantage to virgin paperboard. Adding recycled content to SBS is likely to increase the price.

Three basic types of packages are made from these grades of paperboard, each designed for a different type of product. Folding cartons are made from all three types of paperboard and are used as mass-produced consumer packaging. Set-up boxes are made principally from recycled paperboard and are custom-designed to package products such as liquor and jewelry. Foodboard, more than 90% of which is made from SBS, is used in food containers and milk and juice cartons.[98]

In 1994, 6.1 million tons of paperboard was used in folding cartons and similar uses, 316,000 tons of paperboard was used in set-up boxes, and 1.7 million tons was used in food service and milk and juice cartons. These numbers measure production for domestic use; an additional 1.9 million tons of paperboard used in these types of boxes and cartons was exported in 1994, 67% of which was SBS.[99] Folding cartons are the focus of the Paper Task Force's recommendations. They are a much larger use than set-up boxes. The public health and safety issues associated with direct-contact packaging for fatty and aqueous food tend to limit, although they do not exclude, the use of postconsumer recycled fiber.

Because SBS, CUK and recycled paperboard differ in performance characteristics and price, each tends to be used to package a different set of goods, though there is substantial overlap and competition outside of direct food-contact packaging. SBS is generally used for items that are perishable or for which retailers perceive that a highly printable or smooth, bright white appearance inside and out helps differentiate the product (for example, baked goods, medicine, cosmetics, high-priced toys).

Beverage carriers for beer and soft drink bottles make up about 70% of the use of CUK. CUK is beginning to penetrate other markets, such as frozen foods and hardware.[100] Recycled paperboard is used to package items such as dry foods, which may or may not be packaged with plastic inner liners (for example, cereal, pasta, rice, cookies, crackers and pet food), paper goods (for example, envelopes and stationery), hardware and powdered laundry detergents. Of the 6.2 million tons of paperboard produced for the U.S. folding-carton market in 1994, 2.9 million tons (47%) were recycled, 2.0 million tons were SBS (32%), and 1.3 million tons were CUK (21%).[101]

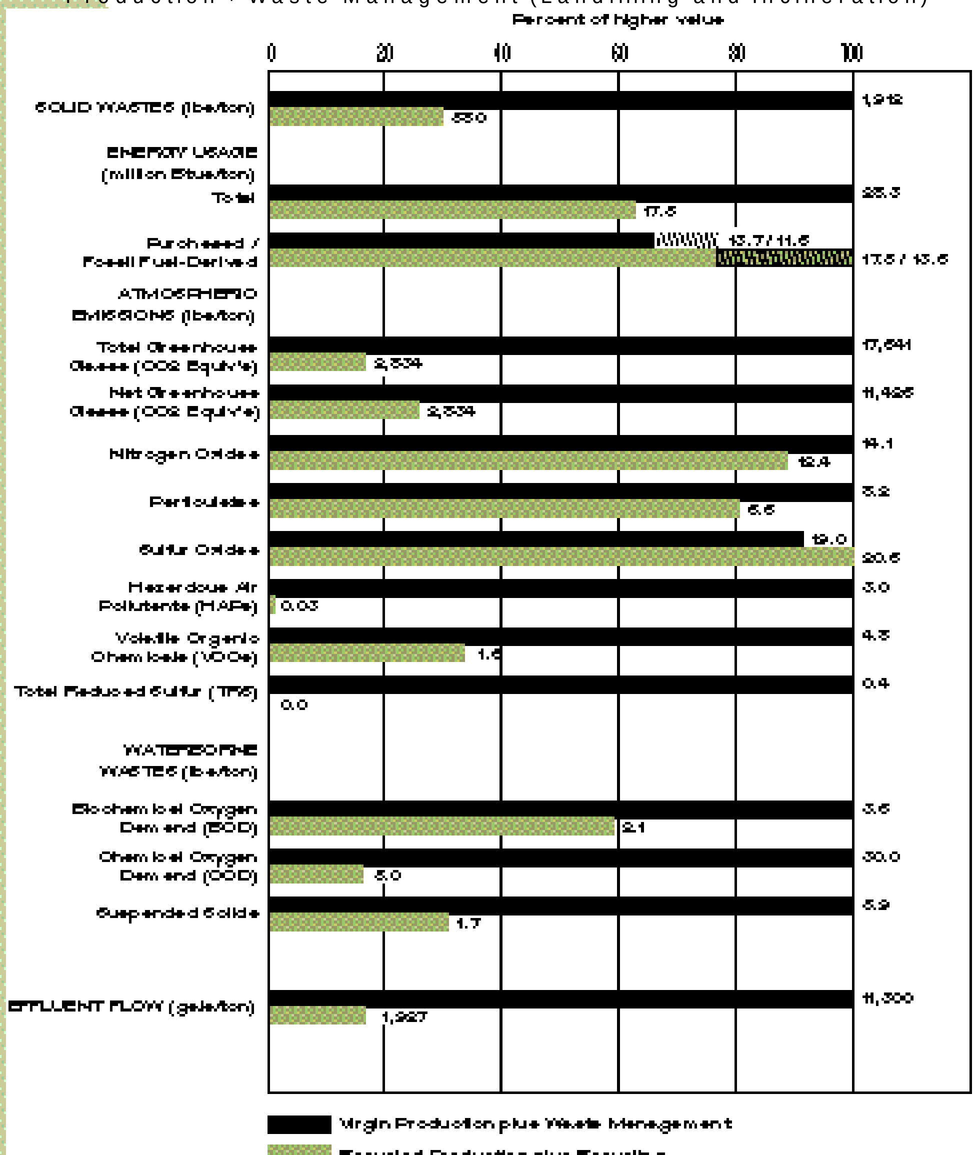
1. Environmental issues

The lifecycle comparison of virgin and recycled paperboard systems developed by the Task Force examined a total of 15 parameters, including total and purchased energy, eight categories of pollutant releases to air and three to water, and quantities of effluent and solid waste. *Ton-for-ton, 100% recycled paperboard is generally found to be preferable to 100% virgin CUK and SBS paperboard. For the comparison between 100% recycled and CUK paperboard, the only exceptions are purchased and fossil fuel-derived energy, where the recycled system exceeds the virgin system by 28% and 17%, respectively, and sulfur oxides, where the two systems are comparable. For the comparison between 100% recycled paperboard and SBS paperboard, this finding holds true across all environmental parameters examined in our analysis except for purchased and fossil fuel-derived energy, where the two systems are comparable.* Figures 8 and 9 show the results from the recycled-CUK and recycled-SBS comparisons, respectively.

Of all the paper grades examined by the Task Force, the environmental benefits of the recycled fiber-based system are the most pronounced and consistent in comparison to SBS. For paperboard that contains a blend of virgin and recycled pulp,

Figure 8–CUK Paperboard

Average Energy Use and Environmental Releases for Managing Paperboard by Recycled Production + Recycling vs. Virgin Production + Waste Management (Landfilling and Incineration)*



*assumes the national proportions of waste (after recycling) managed by landfilling (79.7%) and incineration (20.3%)

the environmental profile would be intermediate to that discussed here and proportional to the relative amounts and types of virgin and recycled pulps.

Mills making recycled paperboard use smaller amounts of total energy compared to mills making virgin paperboard. The recycled mill uses comparable purchased energy to a mill making SBS paperboard, but more than a mill making CUK paperboard. When all of the activities comprising the recycled and virgin lifecycle systems are factored in, the recycled fiber-based system uses comparable purchased energy and much less total energy than the virgin system involving SBS paperboard, but more purchased energy (though still much less total energy) than the virgin system involving CUK paperboard.

Mills making recycled paperboard produce slightly higher amounts of solid waste than do virgin mills making CUK paperboard, but considerably less than virgin mills making SBS paperboard. When the amount of waste avoided by reutilizing most of the fiber in the recovered material is considered, the recycled fiber-based system results in only about 30% and 26% as much solid waste as the CUK and SBS virgin fiber-based systems, respectively.

Finally, virgin CUK and SBS paperboard require 3.3 and 3.5 tons, respectively, of trees (at 50% moisture content) to produce 1 ton of paperboard, depending on the grade.[102] Replacing virgin kraft pulp with pulp made from recovered paper will reduce considerably the number of trees needed to make this grade of paperboard, with concomitant positive impacts on forest resources.

The issue of source reduction vs. recycled content is frequently raised in environmental comparisons of different types of paperboard used in folding cartons. In some cases, using recycled paperboard instead of CUK or SBS requires moving to a higher basis weight. The typical increase is two points in caliper, which translates to paperboard that is 10-20% heavier. New types of stronger, lighter 100% recycled paperboard and innovations in package design mean that increases in basis weight are not inevitable when using recycled paperboard. In many cases, however, increases in basis weight will be required.

The case of recycled paperboard in folding cartons is an exception to the general rule that source reduction is environmentally preferable compared to adding recycled content. This is because, on a ton-for-ton basis, the energy use and environmental releases associated with recycled paperboard are substantially lower than those for CUK and especially SBS, as shown in Figures 8 and 9. The differences are so large that, in general, an individual package made from recycled paperboard will still have lower energy use and environmental releases than an SBS or CUK carton, even if the recycled carton is 10-20% heavier.

2. Performance and availability

In the case of recycled paperboard, "More than half of the products on supermarket shelves are now packaged in cartons using recycled paperboard, and growth in nonfood products has also been good."[103] In other words, the fundamental question of whether recycled paperboard can meet basic functional requirements for many types of consumer product packages is not at issue.

Users of folding cartons are generally concerned with three criteria for the paperboard: appearance ("graphic appeal" or printability), strength (stiffness) and machinability (the ability of the carton to set up and run smoothly and quickly through packaging filling lines). Folding cartons must meet performance requirements through their entire use cycle, including converting and printing, filling and gluing, distribution, retail presentation and use by the final customer. Packaging buyers tend to specify performance criteria for the overall package, rather than for the paperboard itself.

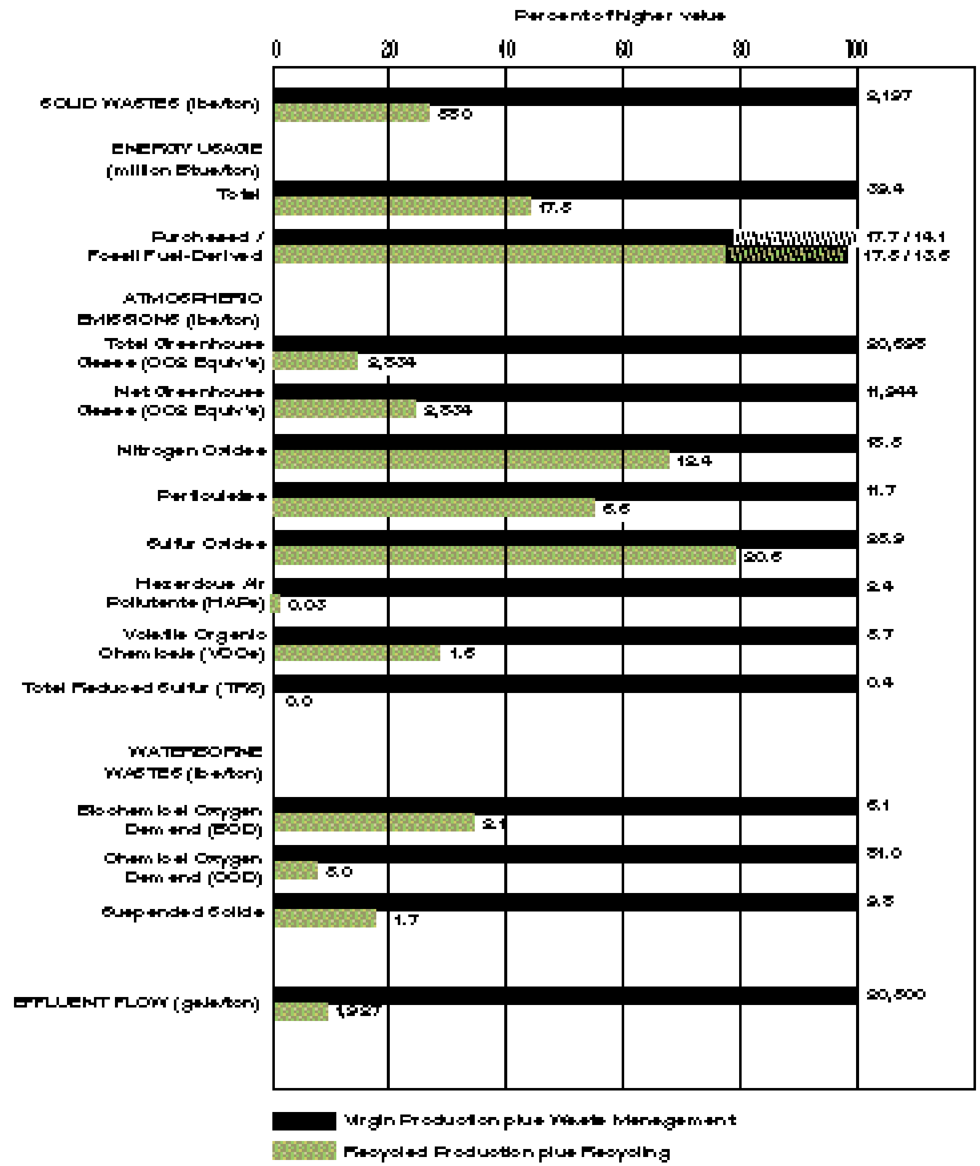
With regard to appearance (printability, smoothness and brightness), SBS offers superior performance compared to CUK and recycled paperboard. The color of the inside of the box (white, brown or gray) appears to be diminishing as a selection factor for some packaging uses.

With regard to strength (stiffness, tear, compression strength, scoring and bending strength) at comparable caliper levels, CUK offers superior characteristics compared to SBS, with recycled paperboard ranked third.

Machinability depends on the type of filling and gluing machines being used, as well as the paperboard. Machinability is most critical when there is a challenging filling environment or when the speed of the filling line is a limiting factor in the overall production of the product. For example, beverage filling lines run at high speeds and tend to create wet and humid conditions. Conventional package filling machines are fairly flexible

Figure 9–SBS Paperboard

Average Energy Use and Environmental Releases for Managing Paperboard by Recycled Production + Recycling vs. Virgin Production + Waste Management (Landfilling and Incineration)*



and can be tuned to compensate for the properties of different types of board. CUK manufacturers state that CUK runs best through modern filling machines that run at very high speeds; SBS manufacturers suggest that their product runs through typical filling machines with the greatest consistency in performance. Within these criteria, performance can vary depending on the mill that manufactures the paperboard.

Advances in forming technology at recycled paperboard mills, such as multifourdrinier machines and ultraformers, can substantially reduce the difference in basis weight between virgin and recycled board. Roughly half of the coated recycled paperboard produced for the U.S. folding carton market is made on modernized machines. Lighter-weight recycled paperboard (12-14 point range) is not available in the same quantities as heavier-weight board. Advances in coating, printing and varnish technology also have increased the quantity of recycled paperboard available for high-quality graphics applications.

The use of recycled paperboard raises concerns in the converting and printing process, but these can be resolved by process modifications and operator experience and training. Recycled paperboard can pose problems with respect to response to moisture (causing curvature of the board) and increased dusting and linting. These can be addressed through proper storage, inventory management and climate control at the converting plant, and by installing vacuuming and dust-collection equipment.

SBS paperboard is available with 10-30% postconsumer recycled content in limited quantities, usually made by adding deinked market pulp. One manufacturer is using a different, proprietary technology that produces an SBS product with recycled content that is suitable for use in aqueous food-contact applications. This manufacturer states that performance specifications for its recycled-content bleached paperboard are the same as for its 100% virgin products.[104] CUK is available with 20-25% recycled content. At these levels of recycled content, manufacturers state that there is no loss in performance characteristics compared to their 100% virgin products.

3. Economics

Recycled paperboard has traditionally sold at a lower price than CUK, and both sell for less than SBS. This reflects both lower manufacturing costs and appearance characteristics for recycled and CUK paperboard and comparatively lower stiffness properties for recycled board. Between 1985 and 1995, per-ton prices for 20 pt. CUK ranged between 72% and 93% of prices for 15 pt. SBS (these are the standard basis weights for which publicly available price data are reported). During the same period, prices for 20 pt. recycled paperboard ranged between 59% and 79% of 15 pt. SBS prices.[105]

Users of folding cartons buy packages from converters, rather than paperboard itself. The design of the carton, the type of printing, the basis weight of paperboard used and other factors will influence the final cost of the package. In 1995, the cost of paperboard made up an estimated 58% of the average total cost of printing and converting folding cartons.[106]

For 100% recycled paperboard producers, the impact of recovered paper prices on total production costs is a key concern. Changing recovered paper costs can make a difference of about $150 per ton for a product with production costs in the $400-500 per ton range. Experience in 1994 and 1995 suggests that most producers of recycled paperboard have been able to raise prices for clay-coated grades sufficient to compensate for rising recovered paper prices.[107] For example, estimated average fiber costs for recycled paperboard producers increased from $96 to $175 per ton of finished product manufactured from 1994 to 1995. Average prices for the same grade of paperboard increased from $597 per ton to $759 per ton in the same period, more than making up the difference.[108] By shifting to lower grades of mixed paper and installing more recovered fiber cleaning equipment, recycled paperboard mills can partially compensate for rising recovered paper prices.

Producing SBS with recycled content by adding deinked market pulp increases production costs. The economic issues are comparable to those for uncoated freesheet, presented previously in the chapter. One operational difference is that SBS producers often manufacture their entire output at food-grade quality, since they do not know the ultimate use of the paperboard they are making. When using deinked market pulp for non-food contact applications, SBS producers must modify their mill operations somewhat.

The two manufacturers of CUK in the United States both produce board with 20-25% recycled content. For these mills, the costs of doing so will be similar to those for linerboard, although possibly higher, since CUK is a more demanding application. Because it is coated with clay, the requirements for smoothness and lack of contamination in the CUK top liner are greater than for linerboard. The proportional effect of changing costs for recovered paper will not be as great for CUK as for linerboard, because overall production costs for CUK are higher than for linerboard. Manufacturing costs for CUK are comparable to recycled paperboard. Prices for CUK, however, are much higher, because of the value-added uses of the product and the effect of having only two producers in a market with strong demand.

4. Recycling of folding cartons

Folding cartons are collected for recycling in a relatively small but growing number of communities in the United States.[109] There is little systematic data on how they are collected or the types of paper mills that use them as a raw material. In a program promoted by recycled paperboard manufacturers in Ontario, citizens can recycle folding cartons through a two-part separation of paper products, with newspapers, magazines, catalogs and telephone directories on one side of a partitioned bin, and corrugated boxes, mail, ledger paper and paperboard packaging on the other.

The most likely candidates for using folding cartons as a feedstock are mills producing different grades of recycled paperboard, unbleached tissue and toweling and construction paper and board. The manufacturing processes at these mills can handle more contaminants compared to other types of paper and paperboard.

Mills that use folding cartons as a feedstock will face higher levels of contaminants, due to the presence of packaging components such as polyethylene coatings, metal tear strips, plastic handles, etc. These problems may be addressed by a number of steps taken at the mill. Packaging designers may be able to reduce some of the contaminants in paperboard packaging that cause problems at recycling mills through their choice of varnishes, adhesives and packaging components.

VI. ANSWERS TO FREQUENTLY ASKED QUESTIONS

As organizations begin to collect their used paper for recycling and buy recycled paper, questions usually arise. This section poses some of the questions the Task Force has often encountered, and provides answers based on our analysis and experience.

1. Why does some printing and writing paper with recycled content cost more?

Considering all types of paper and paperboard produced in the United States, most recycled-content paper does not cost more than comparable grades of virgin paper. Manufacturing printing and writing paper with recycled content often costs about 5-10% more than manufacturing comparable grades of virgin paper in current market conditions. As of mid-1995, the primary reason for this fact was the extremely high cost of recovered paper, although technological factors can also play a role. In order to maintain comparable profit margins for recycled and virgin grades, manufacturers charge more for the paper with recycled content.

Price premiums generally are found only in the case of printing and writing paper. When prices for recovered paper are in their historical range, in many circumstances it costs less to manufacture grades such as newsprint, linerboard, corrugating medium and various types of 100% recycled paperboard compared to competing virgin paper products.

As discussed in the chapter, the economics of producing paper with recycled content can vary from mill to mill. Generally speaking, adding a recovered fiber processing system at a paper mill is most likely to be cost-effective when the mill is expanding its paper production and needs an additional increment of pulp. For integrated virgin mills that are closely balanced in their pulp and paper production, purchasing deinked market pulp is substantially more expensive than manufacturing virgin hardwood kraft pulp.

Price premiums for printing and writing paper with recycled content may decline in the future under certain conditions. For example, in the fall of 1995, market prices for recovered paper declined substantially, and the price of deinked market pulp dropped below that of virgin bleached hardwood kraft market pulp. Collection of significantly more office-type paper for recycling would tend to reduce mills' raw material costs. Competition among manufacturers of deinked pulp and among manufacturers of recycled-content printing and writing paper will tend to reduce or eliminate premiums, especially as the downside of the paper pricing cycle begins. As paper mills expand and technology evolves over time, mill managers will find more economical means of fitting deinking facilities into mill operations.

2. Does paper recycling "save trees?"

Yes, but the effect is more complex than would appear on the surface. Recycling can reduce the number of trees that are harvested for making paper. The real impact of increased recycling should not be considered literally in terms of individual trees, but in terms of changes in forests and forest management practices. Recycled fiber substitutes directly for virgin fiber in the paper sheet and, consequently, reduces the demand for virgin fiber coming from the pulp and paper sector. Trees can also be used to make lumber and other wood products, however; so some of the trees that are not used to make paper due to recycling could end up as wood products or be exported as logs or chips.

Overall, paper recycling helps conserve and extend the virgin fiber base and affects the management of forests in a way that is environmentally positive. This is especially true on a global basis. In regions like Asia and Europe where high recycling rates mean that fibers are recycled multiple times, one ton of recycled fiber would replace the equivalent of several tons of virgin fibers.

3. Don't we have plenty of landfill space? If so, why recycle paper?

While the adequacy of landfill space is as much a political and economic question as an environmental one, the environmental advantages of recycling extend well beyond saving landfill space. Landfills are a source of both air and water pollutants, including, for example, methane (which is a potent "greenhouse gas" and contributor to global climate change) and leachate, which can contaminate groundwater and must be collected and treated, adding to the amount of sludge generated by wastewater treatment plants. As paper degrades in landfills, it contributes to releases of both air and water pollutants. Recycling of paper avoids these releases and reduces the need to site additional landfills thereby reducing the number of locations where those releases might occur.

But more significantly, paper recycling reduces environmental impacts occurring "upstream" of the landfill, in the forest or at the pulp and paper mill. By adding to the available fiber supply, paper recycling moderates the rate and extent of harvesting trees to make paper (see Question 2 above) and the environmental impacts associated with managing forests to produce fiber. By displacing the need to produce more paper made from virgin fiber, paper recycling avoids the environmental impacts (energy use, air and water pollution and solid waste) that arise in making virgin pulp and paper. Paper recycling has its own impacts, of course: used paper must be collected, transported, processed and used to manufacture new pulp and paper. But the Task Force's analysis shows that collecting paper for recycling and making recycled paper provides clear and substantial environmental advantages relative to making virgin paper and disposing of it in landfills (or incinerators). This holds true for all of the grades of paper we examined.

4. Is recycled printing and writing paper inferior in performance compared to virgin paper?

No. The performance of printing and writing papers made with recycled content has improved dramatically since the late 1980's. Because adding recycled fiber to printing and writing paper at large-scale mills is a more recent phenomenon, manufacturers have had to gain experience in incorporating this relatively new type of fiber. There are commodity-grade recycled papers currently available that perform as well as their virgin counterparts for virtually every grade of printing and writing paper. (See also Question 7.)

5. Does recycled-content paper jam in photocopy machines and other office equipment more often than virgin paper?

Major equipment and paper manufacturers state that the incidence of jams in photocopy machines is not attributable to recycled content in paper. Rather, the majority of jams are a function of several factors such as the speed and condition of equipment, the quality of paper being used, two-sided copying, and operator errors.

For example, a "high-quality" paper will likely perform better in office machines than a "low-quality" paper, irrespective of virgin or recycled content. Similarly, the expertise and capabilities of individual manufacturers in producing virgin or recycled papers will affect the performance quality of that specific paper grade.

One of the best ways to ensure that the recycled content paper you buy will perform well in your office machines and be accepted by your staff is to test different brands in your equipment. Such trials can be effective if set up without biases in either direction. Many manufacturers of copy machines also recommend that you try a product, whether virgin or recycled, before making large volume changes. Several Paper Task Force members have conducted controlled tests with recycled photocopy paper and have found products with up to 25% post-consumer recycled content that performed comparably to virgin papers.

6. Does recycled content conflict with source reduction?

Generally speaking, source reduction is environmentally preferable compared to recycling. Recycling-based paper manufacturing results in lower energy use and environmental releases than virgin paper manufacturing across comparable paper grades. However, using less paper or not using paper at all results in correspondingly reduced environmental impacts compared to either manufacturing process.

For folding cartons, in some cases, the use of recycled paperboard in place of virgin paperboard may require a slight increase in the weight of the board. However, this example is an exception to the general rule that source reduction is environmentally preferable compared to adding recycled content. This is because, on a ton-for-ton basis, the energy use and environmental releases associated with recycled paperboard are substantially lower than those for CUK and especially SBS, as shown in Figures 8 and 9. The differences are so large that, in general, an individual package made from recycled paperboard will still have lower energy use and environmental releases than an SBS or CUK carton, even if the recycled carton is 10-20% heavier.

For folding cartons that must be made from CUK or SBS paperboard due to functional considerations, adding recycled content to these grades at the levels that are currently available (10-30%) does not require an increase in the weight of the board.

7. Will printing and writing papers with higher levels of postconsumer content perform the same as virgin papers? Will they be available in the future?

There are uncoated printing and writing papers available today with more than 20% postconsumer content that perform as well as comparable virgin papers. Cost, end use, and availability will affect decisions to buy such papers. There are few data available on the performance of lightweight coated papers with more than 15% postconsumer content. Several paper manufacturers report that it is possible to produce lightweight coated papers with as much as 20% postconsumer content that meet runability and print quality requirements, but cite concerns about (1) the technical difficulty of addressing contamination at higher postconsumer levels; (2) the cost of necessary capital modifications for paper machines; and (3) the cost, availability and variability of postconsumer recovered paper and/or pulp. Customer demand and further technological developments will also influence the evolution of manufacturing capabilities.

8. How many times can paper be recycled?

There are limits to the number of times an individual paper fiber can be recycled, but this does not provide a reason for purchasers to avoid buying paper with recycled content. To understand this issue we must consider two things: what happens to individual paper fibers when they are recycled multiple times, and the overall system of paper use and recycling in the United States.

Depending on how the fiber is handled, recycling over and over does reduce fiber length and strength properties. Repeated fiber processing and cleaning seem to have a greater impact on fibers from kraft pulp compared to fibers from mechanical pulp.[110]

In the real world, however, for the average fiber to be recycled several times, recycling rates must be significantly higher than they currently are in the United States. In 1994, about 70% of the paper *made* in the United States was based on new, virgin fiber. About 66% of the finished paper products used in the United States are disposed in landfills and incinerators. The remaining 34% is collected for recycling, of which about 20% is exported to other countries. Many paper products that contain recycled content, such as tissue and toweling and folding cartons made from 100% recycled paperboard, are usually not collected to be recycled again. Thus, the paper fibers in these products leave the recycling system.

In other words, in the United States, the chances for the same paper fiber to be recycled several times are quite low — a lot of fiber is flowing out of the system and is being replaced by new virgin fiber. This will slowly change as recycling rates rise, but technology and the composition of paper products should be able to adjust gradually through the working of the market.

The most frequently re-recycled fibers are found in corrugated boxes, where the average recycled content is approaching 40% and there is a fair degree of recycling used corrugated boxes back into the same product. However, in the United States, the average fiber in a corrugated box is recycled twice, compared to four times in western Europe.[111]

The repeated recycling of paper fiber is less of an issue for printing and writing papers. For this grade, the large majority of paper is made from virgin fiber, and levels of recycled content in grades that do contain some recycled fiber are relatively low. In addition, the shortest fibers are typically washed out in the fiber cleaning process used by deinking mills, so they have a reduced probability of being recycled again.

9. What is the basis for the distinction between postconsumer and preconsumer recycled content?

Postconsumer materials are finished products that have served their useful lives and would otherwise end up in a landfill or incinerator if not discarded. Preconsumer materials include trim and scrap from manufacturing processes, such as the conversion of rolls of paper into envelopes. In the paper industry, the vast majority of preconsumer paper scrap produced has been recycled for decades. It is environmentally beneficial to recycle both materials, although most purchasers give a greater emphasis to postconsumer content.

The difference between postconsumer used paper and preconsumer scrap is based on their origin. This distinction may not be very important to a paper manufacturer, but it can be very important to a city, business or household that separates its paper to be picked up in recycling collection programs.

As noted the chapter, the Task Force is using the definition of "postconsumer" established by the Federal Resource Recovery and Conservation Act in 1976. This definition is the most widely accepted by purchasers in the private market.

Postconsumer materials are generally more challenging to recycle than preconsumer paper scrap. This is because postconsumer paper items accumulate in smaller quantities in dispersed sites (homes and businesses rather than converting facilities and printing plants). Postconsumer materials are typically more contaminated, varied and unpredictable in their physical characteristics than comparable preconsumer materials. Prices in recovered paper markets generally reflect this reality; for example, cuttings from corrugated box plants usually sell for more than old corrugated containers.

By taking into account the source of recovered paper, the postconsumer definition gives credit in the marketplace to those manufacturers that have made investments that directly increase the recycling of postconsumer materials. For example, without the postconsumer definition, a printing and writing paper manufacturer making 20% recycled content paper from easily recovered clean preconsumer scrap could advertise using the same "recycled" label for its product as a manufacturer that had just made a $100 million investment in deinking technology to use mixed office paper. The new investment in the deinking plant directly expands the infrastructure to use paper that otherwise would go to a landfill, while the continued use of preconsumer material that has long been recycled does not. Using more preconsumer recycled fiber in one product or another may shift fiber use within the overall system, but for additional postconsumer paper to be diverted from disposal, a mill somewhere has to make an investment in equipment to use it.

The postconsumer definition also serves final customers, who may desire that the recycled-content products that they buy are produced with the same type of paper they took the time to separate themselves for a business or community recycling collection program.

10. Why should printing and writing paper contain recycled content — doesn't it make more sense to recycle all of the paper we collect by putting it into lower grades of paper and paperboard?

The overall paper recycling system in the United States is designed for both "like-to-like" recycling, in which recovered paper is used to make the same grade of new paper, and "downcycling," in which recovered paper is used to make paper or paperboard of a lower value or different character than the original product. There is no reason based on the concept of "downcycling" alone for users of printing and writing paper to avoid purchasing paper with recycled content when it meets their functional and economic needs. *Adding recycled content to printing and writing paper grades is essential to significantly expanding paper recycling in the United States from its current position, and pulp and paper manufacturers are already making the investments to do so.*

Most of the finished paper products that are candidates for using higher-grade recovered paper as a raw material already contain 100% recycled content. These products include, for example, brown paper towels, various grades of 100% recycled paperboard, and asphalt roofing felt. These grades cannot absorb any more recovered fiber except that made possible by overall growth in production and sales. The total production and annual sales growth for printing and writing paper is significantly greater than that for the 100% recycled paperboard grades. Trying to add more recycled content to the currently 100% recycled grades would therefore be like pouring water into a bucket that is already full.

To achieve the full potential environmental benefits of paper recycling in the U.S., it is clear that it will be important for some printing and writing paper to contain recycled content. From an economic standpoint, printing and writing paper manufacturers are most likely to be able to support the development of an infrastructure for collecting clean, high-value recovered paper grades. The goal set by the American Forest & Paper Association of recovering 50% of preconsumer and postconsumer paper in the United States in the year 2000, for example, assumes significant growth in recycled content in printing and writing papers.[112]

11. What are the consequences of using printing and writing paper that contains mechanical (e.g., groundwood) pulp for office paper uses?

Some uncoated paper made using mechanical pulp and used in the office for computer forms and photocopy paper can contain recycled content. These papers are usually less expensive and can have higher levels of recycled content than comparable uncoated freesheet papers. There are functional differences between papers made with mechanical and bleached kraft pulps that may or may not be important to the user. Some of these issues are discussed in Chapter 5.

Except in small quantities, paper containing mechanical pulps, such as newsprint, is considered a contaminant in the process of recycling office paper back into printing and writing paper. As deinking technologies improve, this is becoming less of a problem as long as mechanical fibers make up less than 5-10% of the incoming recovered paper. Deinking mills squirt a solution of flouroglucinol onto bales of incoming recovered paper. If this compound turns purple, it indicates the presence of lignin associated with mechanical fibers. The presence of large quantities of papers made from mechanical pulps, such as newsprint, in recovered office paper reduces the market value of the recovered paper. A groundwood/freesheet mix (as one would find in residential mixed paper collection programs) can be recycled into 100% recycled paperboard, for example, but these mills would pay less for the mix.

Ultimately, if businesses are going to use groundwood-containing papers in the office, they should take responsibility for working with their suppliers to ensure that the full range of paper used in the office is collected for recycling. Depending on the location of the business and the amount of paper used, this could mean mixing groundwood and freesheet papers together, developing a program to keep them separate, or finding different markets for the used paper. Individual purchasers of paper will have to make the economic decision of whether the lower cost of papers made using mechanical pulps is worth the potential decrease in value of recovered office paper.

APPENDIX A

Table A-1: Newsprint

Energy, Air Emissions, Solid Waste Outputs, Waterborne Wastes and Water Use Associated with Component Activities of Three Methods for Managing Newsprint

	Virgin Production + Landfilling						Virgin Production + Incineration								Recycled Production + Recycling						
	a	b	c	d	e	f	a	b	c	d	e	f	g	h	a	b	c	d	e	f	g
(Notes)	Tree Harvesting/ Transport	Virgin Mfctr'ing Energy/ Releases	Utility Energy/ Releases (7)	Collection Vehicle & Landfill Equipment	MSW Landfill (1)	Total (per Ton of ONP Landfilled)	Tree Harvesting/ Transport	Virgin Mfctr'ing Energy/ Releases	Utility Energy/ Releases (7)	MSW Collection	W-T-E Combustion Process (2)	Avoided Utility Energy/ Releases (3)	Ash Landfill Disposal (4)	Total (per Ton of ONP Combusted)	ONP Collection (5)	MRF Process (6)	Residue Landfill Disposal	Transport-ation to Market	Utility Energy/ Releases (7)	Recycled Mfctr'ing Energy/ Releases	Total (per Ton of ONP Recycled)
Energy Usage (000 Btus/ton)																					
Total	1,150.0	36,300.0		527.4		37,977.4	1,150.0	36,300.0		296.6	782.8	(8,202.0)	35.6	30,363.0	989.0	282.7	42.2	205.2		19,300.0	20,819.1
Purchased	1,150.0	33,000.0		527.4		34,677.4	1,150.0	33,000.0		296.6	33.0	(8,202.0)	35.6	26,313.2	989.0	282.7	42.2	205.2		19,300.0	20,819.1
Fossil Fuel-Derived	1,150.0	24,624.6		527.4		26,302.0	1,150.0	24,624.6		296.6	33.0	(8,202.0)	35.6	17,937.8	989.0	282.0	42.2	205.2		15,088.1	16,606.5
Environmental Releases (lbs/ton)																					
Atmospheric Emissions																					
Total Greenhouse Gases (CO2 Equivalents) [9]	183.8	5,946.0		84.1	11,626.7	17,840.5	183.8	5,946.0		47.3	2,207.1	(1,024.8)	5.7	7,365.0	157.7	31.7	6.7	33.0		3,232.0	3,461.1
Net Greenhouse Gases (CO2 Equivalents) [10]	183.8	5,300.0		84.1	11,152.0	16,719.9	183.8	5,300.0		47.3	5.3	(1,024.8)	5.7	4,517.2	157.7	31.7	6.7	33.0		3,232.0	3,461.1
Nitrogen Oxides	2.2	21.1		1.0		24.3	2.2	21.1		0.57	1.8	(4.7)	0.07	21.1	1.9	0.17	0.08	0.28		12.4	14.9
Particulates	0.49	13.1		0.23		13.8	0.49	13.1		0.13	0.27	(3.4)	0.02	10.7	0.43	0.11	0.02	0.05		6.6	7.2
Sulfur Oxides	0.31	41.4		0.14		41.9	0.31	41.4		0.08	0.39	(8.8)	0.01	33.4	0.27	0.29	0.01	0.06		24.1	24.7
Hazardous Air Pollutants (HAPs)[8]		0.43				0.43		0.43						0.43						0.15	0.15
Volatile Organic Chemicals (VOCs)[8]		3.9				3.9		3.9						3.9						1.7	1.7
Solid Wastes	0.6	362.0	444.2	0.26	2,000.0	2,807.0	0.6	362.0	444.2	0.15	180.0	(122.6)	0.02	864.3	0.49	163.8	0.02	0.10	223.4	530.0	917.8
Waterborne Wastes																					
Biochemical Oxygen Demand (BOD)	0.0008	2.5	0.0024	0.0003		2.5	0.0008	2.5	0.0024	0.0002		(0.0007)	0.0000	2.5	0.0006	0.0002	0.0000	0.0002	0.0012	6.1	6.1
Chemical Oxygen Demand (COD)	0.0031	36.3	0.0073	0.0016		36.3	0.0031	36.3	0.0073	0.0008		(0.0019)	0.0001	36.3	0.0030	0.0005	0.0001	0.0006	0.0037	27.5	27.5
Suspended Solids	0.0008	4.8	0.0048	0.0003		4.8	0.0008	4.8	0.0048	0.0002		(0.0014)	0.0000	4.8	0.0006	0.0000	0.0000	0.0002	0.0024	6.9	6.9
Effluent Flow (gals/ton)[8]		14,172				14,172		14,172						14,172						19,304	19,304

NOTES:
(1) Landfill gas collected for energy recovery not included.
Only carbon dioxide and methane in landfill gas are included in atmospheric emissions; methane has been converted to carbon dioxide equivalents using a molecular ratio of 25:1 and a weight ratio of 69:1.
Waterborne wastes caused by leachate from landfills not included.
(2) Air emissions based on new source performances standards (NSPS) for combustors > 250 tpd.
(3) Values in parentheses represent energy and environmental releases from a utility avoided due to energy generation by incineration.
Assumes 670 kwh of electricity generated by a utility is avoided by combusting one ton of ONP.
Avoided releases based on fuel mix for national electricity energy grid.
(4) Waterborne wastes caused by leachate from ash landfills not included.
Assumes burning ONP yields 9 percent ash residue by dry weight, 25 percent moisture content as disposed.
(5) Assumes curbside collection of ONP.
(6) Assumes ONP is processed at a material recovery facility (MRF); values based on average of low tech and high tech MRF.
(7) Values represent the solid waste and waterborne wastes associated with utility generation of electricity purchased by the recycled or the virgin pulp and paper mill; energy and air emissions have been incorporated into the adjacent manufacturing energy/releases column.
Releases incurred or avoided are based on fuel mix for national electricity energy grid.
(8) Values for this parameter are reported by the cited sources only for the virgin and recycled manufacturing processes.
(9) Total greenhouse gases include CO2 emissions from combustion of both wood-derived materials (including paper) and fossil fuels as well as CO2 and methane emissions from landfills.
(10) Net greenhouse gases include CO2 emissions from combustion of fossil fuels and methane emissions from landfills; see text for full explanation.

SOURCES:

(1) VIRGIN PRODUCTION + LANDFILLING:
Column a: PTF calculations based on Franklin Associates, 1994 (for fuel-related release factors) and Argonne, 1993 (for energy use estimates).
Column b: PTF calculations (detailed in White Paper 10A), based on sources provided therein.
Column c: Franklin Associates, 1994 and PTF calculations (detailed in White Paper 10A), based on sources sited therein.
Columns d-e: Franklin Associates, 1994, with adjustments made to greenhouse gas data in column e as explained in Note 1 and White Paper 3.

(2) VIRGIN PRODUCTION + INCINERATION:
Column a: PTF calculations based on Franklin Associates, 1994 (for fuel-related release factors) and Argonne, 1993 (for energy use estimates).
Column b: PTF calculations (detailed in White Paper 10A), based on sources provided therein.
Column c: Franklin Associates, 1994 and PTF calculations (detailed in White Paper 10A), based on sources cited therein.
Columns d-g: Franklin Associates, 1994, with adjustments made to columns d-f as explained in White Paper 3.

(3) RECYCLED PRODUCTION + RECYCLING:
Columns a-d: Franklin Associates, 1994.
Column e: Franklin Associates and PTF calculations (detailed in White Paper 10A), based on sources cited therein.
Column f: PTF calculations (detailed in White Paper 10A), based on sources provided therein.

References cited:
Franklin Associates: The Role of Recycling in Integrated Solid Waste Management to the Year 2000, prepared for Keep America Beautiful, Stamford, CT, September 1994, Chapter 6, Appendix I.
Argonne: Stodolsky, F. and M.M. Mintz (1993) Energy Life-Cycle Analysis of Newspaper, Energy Systems Division, Argonne National Laboratory, U.S. Department of Energy, May 1993.

Table A-2: Office Paper

Energy, Air Emissions, Solid Waste Outputs, Waterborne Wastes and Water Use Associated with Component Activities of Three Methods for Managing Office Paper

	Virgin Production + Landfilling						Virgin Production + Incineration								Recycled Production + Recycling						
	a	b	c	d	e	f	a	b	c	d	e	f	g	h	a	b	c	d	e	f	g
(Notes)	Tree Harvesting/ Transport	Virgin Mfctr'ing Energy/ Releases	Utility Energy/ Releases (7)	Collection Vehicle & Landfill Equipment	MSW Landfill (1)	Total (per Ton of OWP Landfilled)	Tree Harvesting/ Transport	Virgin Mfctr'ing Energy/ Releases	Utility Energy/ Releases (7)	MSW Collection	W-T-E Combustion Process (2)	Avoided Utility Energy/ Releases (3)	Ash Landfill Disposal (4)	Total (per Ton of OWP Combusted)	OWP Collection (5)	MRF Process (6)	Residue Landfill Disposal	Transport-ation to Market	Utility Energy/ Releases (7)	Recycled Mfctr'ing Energy/ Releases	Total (per Ton of OWP Recycled)
Energy Usage (000 Btus/ton)																					
Total	1,908.5	36,800.0		527.4		39,235.9	1,908.5	36,800.0		296.6	782.8	(7,176.8)	98.9	32,710.0	989.0	282.7	42.2	205.2		19,800.0	21,319.1
Purchased	1,908.5	17,200.0		527.4		19,635.9	1,908.5	17,200.0		296.6	33.0	(7,176.8)	98.9	12,360.2	989.0	282.7	42.2	205.2		19,800.0	21,319.1
Fossil Fuel-Derived	1,908.5	13,094.7		527.4		15,530.6	1,908.5	13,094.7		296.6	33.0	(7,176.8)	98.9	8,254.9	989.0	282.0	42.2	205.2		15,307.1	16,825.5
Environmental Releases (lbs/ton)																					
Atmospheric Emissions																					
Total Greenhouse Gases (CO2 Equivalents) [9]	305.0	10,163.0		84.1	11,626.7	22,178.7	305.0	10,163.0		47.3	2,207.1	(896.7)	15.7	11,841.4	157.7	31.7	6.7	33.0		3,345.0	3,574.1
NetGreenhouseGases (CO2 Equivalents) [10]	305.0	2,868.0		84.1	11,152.0	14,409.1	305.0	2,868.0		47.3	5.3	(909.3)	15.7	2,332.0	157.7	31.7	6.7	33.0		3,345.0	3,574.1
Nitrogen Oxides	3.7	14.1		1.0		18.8	3.7	14.1		0.57	1.3	(4.1)	0.19	15.8	1.9	0.17	0.08	0.28		12.2	14.7
Particulates	0.8	11.7		0.23		12.7	0.8	11.7		0.13	0.27	(2.9)	0.04	10.0	0.43	0.11	0.02	0.05		6.7	7.3
Sulfur Oxides	0.5	26.6		0.14		27.3	0.5	26.6		0.08	0.39	(7.7)	0.03	19.9	0.27	0.29	0.01	0.06		24.8	25.4
Hazardous Air Pollutants (HAPs)[8]		2.2				2.2		2.2						2.2						0.15	0.2
Volatile Organic Chemicals (VOCs)[8]		5.4				5.4		5.4						5.4						1.7	1.7
Total Reduced Sulfur (TRS)[8]		0.3				0.3		0.34						0.3						0.0	0.0
Solid Wastes	1.0	400.0	217.7	0.26	2,000.0	2,618.9	1.0	400.0	217.7	0.15	500.0	(107.3)	0.05	1,011.6	0.49	163.8	0.02	0.10	238.3	752.0	1,154.7
Waterborne Wastes																					
Absorbable Organic Halogens (AOX) [8]		2.6				2.6		2.6						2.6						0.0	0.0
Biochemical Oxygen Demand (BOD)	0.0013	6.1	0.0012	0.0003		6.1	0.0013	6.1	0.0012	0.0002		(0.0006)	0.0001	6.1	0.0006	0.0002	0.0000	0.0002	0.0013	6.1	6.1
Chemical Oxygen Demand (COD)	0.0051	89.2	0.0036	0.0016		89.2	0.0051	89.2	0.0036	0.0008		(0.0017)	0.0002	89.2	0.0030	0.0005	0.0001	0.0006	0.0039	27.6	27.6
Suspended Solids	0.0013	9.8	0.0024	0.0003		9.8	0.0013	9.8	0.0024	0.0002		(0.0012)	0.0001	9.8	0.0006	0.0000	0.0000	0.0002	0.0026	6.9	6.9
Effluent Flow (gals/ton)[8]		20,500				20,500		20,500						20,500						19,304	19,304

NOTES:
(1) Landfill gas collected for energy recovery not included.
Only carbon dioxide and methane in landfill gas are included in atmospheric emissions; methane has been converted to carbon dioxide equivalents using a molecular ratio of 25:1 and a weight ratio of 69:1.
Waterborne wastes caused by leachate from landfills not included.
(2) Air emissions based on new source performances standards (NSPS) for combustors > 250 tpd.
(3) Values in parentheses represent energy and environmental releases from a utility avoided due to energy generation by incineration.
Assumes 594 kwh of electricity generated by a utility is avoided by combusting one ton of OWP.
Avoided releases based on fuel mix for national electricity energy grid.
(4) Waterborne wastes caused by leachate from ash landfills not included.
Assumes burning OWP yields 25 percent ash residue by dry weight, 25 percent moisture content as disposed.
(5) Assumes curbside collection of OWP.
(6) Assumes OWP is processed at a material recovery facility (MRF); values based on average of low tech and high tech MRF.
(7) Values represent the solid waste and waterborne wastes associated with utility generation of electricity purchased by the virgin or recycled pulp and paper mill; energy and air emissions have been incorporated into the adjacent manufacturing energy/releases column.
Releases incurred or avoided are based on fuel mix for national electricity energy grid.
(8) Values for this parameter are reported by the cited sources only for the virgin and recycled manufacturing processes.
(9) Total greenhouse gases include CO2 emissions from combustion of both wood-derived materials (including paper) and fossil fuels as well as CO2 and methane emissions from landfills.
(10) Net greenhouse gases include CO2 emissions from combustion of fossil fuels and methane emissions from landfills; see text for full explanation.

SOURCES:

(1) VIRGIN PRODUCTION + LANDFILLING:
Column a: PTF calculations based on Franklin Associates, 1994 (for fuel-related release factors) and Argonne, 1993 (for energy use estimates).
Column b: PTF calculations (detailed in White Paper 10A), based on sources provided therein.
Column c: Franklin Associates, 1994 and PTF calculations (detailed in White Paper 10A), based on sources cited therein.
Columns d-e: Franklin Associates, 1994, with adjustments made to greenhouse gas data in column e as explained in Note 1 and White Paper 3.

(2) VIRGIN PRODUCTION + INCINERATION:
Column a: PTF calculations based on Franklin Associates, 1994 (for fuel-related release factors) and Argonne, 1993 (for energy use estimates).
Column b: PTF calculations (detailed in White Paper 10A), based on sources provided therein.
Column c: Franklin Associates, 1994 and PTF calculations (detailed in White Paper 10A), based on sources cited therein.
Columns d-g: Franklin Associates, 1994, with adjustments made to columns d-f as explained in White Paper 3.

(3) RECYCLED PRODUCTION + RECYCLING:
Columns a-d: Franklin Associates, 1994.
Column e: Franklin Associates and PTF calculations (detailed in White Paper 10A), based on sources cited therein.
Column f: PTF calculations (detailed in White Paper 10A), based on sources provided therein.

Table A-3: Corrugated Boxes

Energy, Air Emissions, Solid Waste Outputs, Waterborne Wastes and Water Use Associated with Component Activities of Three Methods for Managing Corrugated

(Notes)	Virgin Production + Landfilling						Virgin Production + Incineration								Recycled Production + Recycling						
	a	b	c	d	e	f	a	b	c	d	e	f	g	h	a	b	c	d	e	f	g
	Tree Harvesting/ Transport	Virgin Mfctr'ing Energy/ Releases	Utility Energy/ Releases (7)	Collection Vehicle & Landfill Equipment	MSW Landfill (1)	Total (per Ton of OCC Landfilled)	Tree Harvesting/ Transport	Virgin Mfctr'ing Energy/ Releases	Utility Energy/ Releases (7)	MSW Collection	W-T-E Combustion Process (2)	Avoided Utility Energy/ Releases (3)	Ash Landfill Disposal (4)	Total (per Ton of OCC Combusted)	OCC Collection (5)	MRF Process (6)	Residue Landfill Disposal	Transport-ation to Market	Utility Energy/ Releases (7)	Recycled Mfctr'ing Energy/ Releases	Total (per Ton of OCC Recycled)
Energy Usage (000 Btus/ton)																					
Total	1,643.0	26,766.7		527.4		28,937.1	1,643.0	26,766.7		296.6	782.8	(7,176.8)	35.6	22,347.9	989.0	282.7	42.2	205.2		16,866.7	18,385.8
Purchased	1,643.0	14,222.2		527.4		16,392.6	1,643.0	14,222.2		296.6	33.0	(7,176.8)	35.6	9,053.7	989.0	282.7	42.2	205.2		16,866.7	18,385.8
Fossil Fuel-Derived	1,643.0	12,004.3		527.4		14,174.7	1,643.0	12,004.3		296.6	33.0	(7,176.8)	35.6	6,835.7	989.0	282.0	42.2	205.2		13,798.2	15,316.6
Environmental Releases (lbs/ton)																					
Atmospheric Emissions																					
Total Greenhouse Gases (CO2 Equivalents) [9]	262.5	6,918.2		84.1	11,626.7	18,891.5	262.5	6,918.2		47.3	2,207.1	(896.7)	5.7	8,544.1	157.7	31.7	6.7	33.0		2,951.0	3,180.1
Net Greenhouse Gases (CO2 Equivalents) [10	262.5	2,560.6		84.1	11,152.0	14,059.2	262.5	2,560.6		47.3	5.3	(909.3)	5.7	1,972.0	157.7	31.7	6.7	33.0		2,951.0	3,180.1
Nitrogen Oxides	3.2	10.6		1.0		14.8	3.2	10.6		0.57	1.3	(4.1)	0.07	11.6	1.9	0.17	0.08	0.28		9.8	12.3
Particulates	0.7	7.4		0.23		8.3	0.7	7.4		0.13	0.27	(2.9	0.02	5.6	0.4	0.11	0.02	0.05		5.0	5.6
Sulfur Oxides	0.4	20.9		0.14		21.5	0.45	20.9		0.08	0.39	(7.7)	0.01	14.1	0.3	0.29	0.01	0.06		21.1	21.7
Hazardous Air Pollutants (HAPs)[8]		3.4				3.4		3.4						3.4						0.002	0.002
Volatile Organic Chemicals (VOCs)[8]		6.5				6.5		6.5						6.5						0.5	0.5
Total Reduced Sulfur (TRS)[8]		0.21				0.2		0.21						0.2						0.00	0.0
Solid Wastes	0.8	200.7	117.6	0.26	2,000.0	2,319.4	0.8	200.7	117.6	0.15	180.0	(107.3)	0.02	392.0	0.49	163.8	0.02	0.10	162.7	210.0	537.2
Waterborne Wastes																					
Biochemical Oxygen Demand (BOD)	0.0011	3.7	0.0006	0.0003		3.7	0.0011	3.7	0.0006	0.0002		(0.0006)	0.0000	3.7	0.0006	0.0002	0.0000	0.0002	0.0009	3.6	3.6
Chemical Oxygen Demand (COD)	0.0044	N/A [11]	0.0019	0.0016		N/A [11]	0.0044	N/A [11]	0.0019	0.0008		(0.0017)	0.0001	N/A [11]	0.0030	0.0005	0.0001	0.0006	0.0027	N/A [11]	N/A[11]
Suspended Solids	0.0011	5.8	0.0013	0.0003		5.8	0.0011	5.8	0.0013	0.0002		(0.0012)	0.0000	5.8	0.0006	0.0000	0.0000	0.0002	0.0018	1.8	1.8
Effluent Flow (gals/ton)[8]		9,779				9,779		9,779						9,779						1,927	1,927

NOTES:
(1) Landfill gas collected for energy recovery not included.
Only carbon dioxide and methane in landfill gas are included in atmospheric emissions; methane has been converted to carbon dioxide equivalents using a molecular ratio of 25:1 and a weight ratio of 69:1.
Waterborne wastes caused by leachate from landfills not included.
(2) Air emissions based on new source performances standards (NSPS) for combustors > 250 tpd.
(3) Values in parentheses represent energy and environmental releases from a utility avoided due to energy generation by incineration.
Assumes 594 kwh of electricity generated by a utility is avoided by combusting one ton of OCC.
Avoided releases based on fuel mix for national electricity energy grid.
(4) Waterborne wastes caused by leachate from ash landfills not included.
Assumes burning OCC yields 9 percent ash residue by dry weight, 25 percent moisture content as disposed.
(5) Assumes curbside collection of OCC.
(6) Assumes OCC is processed at a material recovery facility (MRF); values based on average of low tech and high tech MRF.
(7) Values represent the solid waste and waterborne wastes associated with utility generation of electricity purchased
by the virgin or recycled pulp and paper mill; energy and air emissions have been incorporated into the adjacent manufacturing energy/releases column.
Releases incurred or avoided are based on fuel mix for national electricity energy grid.
(8) Values for this parameter are reported by the cited sources only for the virgin and recycled manufacturing processes.
(9) Total greenhouse gases include CO2 emissions from combustion of both wood-derived materials (including paper) and fossil fuels as well as CO2 and methane emissions from landfills.
(10) Net greenhouse gases include CO2 emissions from combustion of fossil fuels and methane emissions from landfills; see text for full explanation.
(11) Data are insufficient to allow calculation of a reliable estimate for average release.

SOURCES:

(1) VIRGIN PRODUCTION + LANDFILLING:
Column a: PTF calculations based on Franklin Associates, 1994 (for fuel-related release factors) and Argonne, 1993 (for energy use estimates).
Column b: PTF calculations (detailed in White Paper 10B), based on sources provided therein.
Column c: Franklin Associates, 1994 and PTF calculations (detailed in White Paper 10B), based on sources cited therein.
Columns d-e: Franklin Associates, 1994, with adjustments made to greenhouse gas data in column e as explained in Note 1 and White Paper 3.

(2) VIRGIN PRODUCTION + INCINERATION:
Column a: PTF calculations based on Franklin Associates, 1994 (for fuel-related release factors) and Argonne, 1993 (for energy use estimates).
Column b: PTF calculations (detailed in White Paper 10B), based on sources provided therein.
Column c: Franklin Associates, 1994 and PTF calculations (detailed in White Paper 10B), based on sources cited therein.
Columns d-g: Franklin Associates, 1994, with adjustments made to columns d-f as explained in White Paper 3.

(3) RECYCLED PRODUCTION + RECYCLING:
Columns a-d: Franklin Associates, 1994.
Column e: Franklin Associates and PTF calculations (detailed in White Paper 10B), based on sources cited therein.
Column f: PTF calculations (detailed in White Paper 10B), based on sources provided therein.

Table A-4: CUK Paperboard

Energy, Air Emissions, Solid Waste Outputs, Waterborne Wastes and Water Use Associated with Component Activities of Three Methods for Managing CUK Paperboard

Virgin Production + Landfilling

(Notes)	a Tree Harvesting/ Transport	b Virgin Mfctr'ing Energy/ Releases	c Utility Energy/ Releases (7)	d Collection Vehicle & Landfill Equipment	e MSW Landfill (1)	f Total (per Ton of OWP Landfilled)
Energy Usage (000 Btus/ton)						
Total	1,815.8	27,400.0		527.4		29,743.2
Purchased	1,815.8	12,930.0		527.4		15,273.2
Fossil Fuel-Derived	1,815.8	10,895.1		527.4		13,238.3
Environmental Releases (lbs/ton)						
Atmospheric Emissions						
Total Greenhouse Gases (CO2 Equivalents) [9]	290.1	7,757.0		84.1	11,626.7	19,757.9
Net Greenhouse Gases (CO2 Equivalents) [10]	290.1	2,369.0		84.1	11,152.0	13,895.2
Nitrogen Oxides	3.5	10.2		1.0		14.7
Particulates	0.8	7.8		0.23		8.8
Sulfur Oxides	0.5	20.0		0.14		20.6
Hazardous Air Pollutants (HAPs)[8]		3.0				3.0
Volatile Organic Chemicals (VOCs)[8]		4.8				4.8
Total Reduced Sulfur (TRS)[8]		0.35				0.4
Solid Wastes	0.9	182.0	107.9	0.26	2,000.0	2,291.1
Waterborne Wastes						
Biochemical Oxygen Demand (BOD)	0.0012	3.6	0.0006	0.0003		3.6
Chemical Oxygen Demand (COD)	0.0049	30.0	0.0018	0.0016		30.0
Suspended Solids	0.0012	5.9	0.0012	0.0003		5.9
Effluent Flow (gals/ton)[8]		11,300				11,300

Virgin Production + Incineration

(Notes)	a Tree Harvesting/ Transport	b Virgin Mfctr'ing Energy/ Releases	c Utility Energy/ Releases (7)	d MSW Collection	e W-T-E Combustion Process (2)	f Avoided Utility Energy/ Releases (3)	g Ash Landfill Disposal (4)	h Total (per Ton of Paperboard Combusted)
Energy Usage (000 Btus/ton)								
Total	1,815.8	27,400.0		296.6	782.8	(7,821.7)	49.1	22,522.7
Purchased	1,815.8	12,930.0		296.6	33.0	(7,821.7)	49.1	7,302.9
Fossil Fuel-Derived	1,815.8	10,895.1		296.6	33.0	(7,821.7)	49.1	5,268.0
Environmental Releases (lbs/ton)								
Atmospheric Emissions								
Total Greenhouse Gases (CO2 Equivalents) [9]	290.1	7,757.0		47.3	2,207.1	(977.2)	7.8	9,332.1
Net Greenhouse Gases (CO2 Equivalents) [10]	290.1	2,369.0		47.3	5.3	(981.9)	7.8	1,737.6
Nitrogen Oxides	3.5	10.2		0.57	1.8	(4.5)	0.10	11.8
Particulates	0.8	7.8		0.13	0.27	(3.2)	0.02	5.8
Sulfur Oxides	0.50	20.0		0.08	0.39	(8.4)	0.01	12.6
Hazardous Air Pollutants (HAPs)[8]		3.0						3.0
Volatile Organic Chemicals (VOCs)[8]		4.8						4.8
Total Reduced Sulfur (TRS)[8]		0.35						0.4
Solid Wastes	0.9	182.0	107.9	0.15	248.4	(117.0)	0.02	422.4
Waterborne Wastes								
Biochemical Oxygen Demand (BOD)	0.0012	3.6	0.0006	0.0002		(0.0007)	0.0001	3.6
Chemical Oxygen Demand (COD)	0.0049	30.0	0.0018	0.0008		(0.0019)	0.0001	30.0
Suspended Solids	0.0012	5.9	0.0012	0.0002		0.0000	0.0000	5.9
Effluent Flow (gals/ton)[8]		11,300						11,300

Recycled Production + Recycling

(Notes)	a Paperboard Collection (5)	b MRF Process (6)	c Residue Landfill Disposal	d Transport-ation to Market	e Utility Energy/ Releases (7)	f Recycled Mfctr'ing Energy/ Releases	g Total (per Ton of Paperboard Recycled)
Energy Usage (000 Btus/ton)							
Total	989.0	282.7	42.2	205.2		16,000.0	17,519.1
Purchased	989.0	282.7	42.2	205.2		16,000.0	17,519.1
Fossil Fuel-Derived	989.0	282.0	42.2	205.2		12,124.0	13,642.4
Environmental Releases (lbs/ton)							
Atmospheric Emissions							
Total Greenhouse Gases (CO2 Equivalents) [9]	157.7	31.7	6.7	33.0		2,605.0	2,834.1
Net Greenhouse Gases (CO2 Equivalents) [10]	157.7	31.7	6.7	33.0		2,605.0	2,834.1
Nitrogen Oxides	1.9	0.17	0.08	0.28		9.9	12.4
Particulates	0.4	0.11	0.02	0.05		6.0	6.6
Sulfur Oxides	0.3	0.29	0.01	0.06		20.0	20.6
Hazardous Air Pollutants (HAPs)[8]						0.0	0.0
Volatile Organic Chemicals (VOCs)[8]						1.6	1.6
Total Reduced Sulfur (TRS)[8]						0.0	0.0
Solid Wastes	0.49	163.8	0.02	0.10	205.6	209.8	579.8
Waterborne Wastes							
Biochemical Oxygen Demand (BOD)	0.0006	0.0002	0.0000	0.0002	0.0011	2.1	2.1
Chemical Oxygen Demand (COD)	0.0030	0.0005	0.0001	0.0006	0.0034	5.0	5.0
Suspended Solids	0.0006	0.0000	0.0000	0.0002	0.0022	1.7	1.7
Effluent Flow (gals/ton)[8]						1,927	1,927

NOTES:
(1) Landfill gas collected for energy recovery not included.
Only carbon dioxide and methane in landfill gas are included in atmospheric emissions; methane has been converted to carbon dioxide equivalents using a molecular ratio of 25:1 and a weight ratio of 69:1.
Waterborne wastes caused by leachate from landfills not included.
(2) Air emissions based on new source performances standards (NSPS) for combustors > 250 tpd.
(3) Values in parentheses represent energy and environmental releases from a utility avoided due to energy generation by incineration.
Assumes 642 kwh of electricity generated by a utility is avoided by combusting one ton of material.
Avoided releases based on fuel mix for national electricity energy grid.
(4) Waterborne wastes caused by leachate from ash landfills not included.
Assumes burning yields 13 percent ash residue by dry weight, 25 percent moisture content as disposed.
(5) Assumes curbside collection of material.
(6) Assumes material is processed at a material recovery facility (MRF); values based on average of low tech and high tech MRF.
(7) Values represent the solid waste and waterborne wastes associated with utility generation of electricity purchased by the virgin or recycled and paper mill; energy and air emissions have been incorporated into the adjacent manufacturing energy/releases column.
Releases incurred or avoided are based on fuel mix for national electricity energy grid.
(8) Values for this parameter are reported by the cited sources only for the virgin and recycled manufacturing processes.
(9) Total greenhouse gases include CO2 emissions from combustion of both wood-derived materials (including paper) and fossil fuels as well as CO2 and methane emissions from landfills.
(10) Net greenhouse gases include CO2 emissions from combustion of fossil fuels and methane emissions from landfills; see text for full explanation.

SOURCES:

(1) VIRGIN PRODUCTION + LANDFILLING:
Column a: PTF calculations based on Franklin Associates, 1994 (for fuel-related release factors) and Argonne, 1993 (for energy use estimates).
Column b: PTF calculations (detailed in White Paper 10C), based on sources provided therein.
Column c: Franklin Associates, 1994 and PTF calculations (detailed in White Paper 10C), based on sources cited therein.
Columns d-e: Franklin Associates, 1994, with adjustments made to greenhouse gas data in column e as explained in Note 1 and White Paper 3.

(2) VIRGIN PRODUCTION + INCINERATION:
Column a: PTF calculations based on Franklin Associates, 1994 (for fuel-related release factors) and Argonne, 1993 (for energy use estimates).
Column b: PTF calculations (detailed in White Paper 10C), based on sources provided therein.
Column c: Franklin Associates, 1994 and PTF calculations (detailed in White Paper 10C), based on sources cited therein.
Columns d-g: Franklin Associates, 1994, with adjustments made to columns d-f as explained in White Paper 3.

(3) RECYCLED PRODUCTION + RECYCLING:
Columns a-d: Franklin Associates, 1994.
Column e: Franklin Associates and PTF calculations (detailed in White Paper 10C), based on sources cited therein.
Column f: PTF calculations (detailed in White Paper 10C), based on sources provided therein.

Table A–5: SBS Paperboard

Energy, Air Emissions, Solid Waste Outputs, Waterborne Wastes and Water Use Associated with Component Activities of Three Methods for Managing SBS Paperboard

	Virgin Production + Landfilling						Virgin Production + Incineration								Recycled Production + Recycling						
	a	b	c	d	e	f	a	b	c	d	e	f	g	h	a	b	c	d	e	f	g
(Notes)	Tree Harvesting/ Transport	Virgin Mfctr'ing Energy/ Releases	Utility Energy/ Releases (7)	Collection Vehicle & Landfill Equipment	MSW Landfill (1)	Total (per Ton of Paperboard Landfilled)	Tree Harvesting/ Transport	Virgin Mfctr'ing Energy/ Releases	Utility Energy/ Releases (7)	MSW Collection	W-T-E Combustion Process (2)	Avoided Utility Energy/ Releases (3)	Ash Landfill Disposal (4)	Total (per Ton of Paperboard Combusted)	Paperboard Collection (5)	MRF Process (6)	Residue Landfill Disposal	Transport-ation to Market	Utility Energy/ Releases (7)	Recycled Mfctr'ing Energy/ Releases	Total (per Ton of Paperboard Recycled)
Energy Usage (000 Btus/ton)																					
Total	1,908.5	38,400.0		527.4		40,825.9	1,908.5	36,400.0		296.6	782.8	(7,821.7)	49.1	33,615.4	989.0	282.7	42.2	205.2		16,000.0	17,519.1
Purchased	1,908.5	16,900.0		527.4		19,335.9	1,908.5	16,900.0		296.6	33.0	(7,821.7)	49.1	11,365.6	989.0	282.7	42.2	205.2		16,000.0	17,519.1
Fossil Fuel-Derived	1,908.5	13,250.1		527.4		15,686.0	1,908.5	13,250.1		296.6	33.0	(7,821.7)	49.1	7,715.6	989.0	282.0	42.2	205.2		12,124.0	13,642.4
Environmental Releases (lbs/ton)																					
Atmospheric Emissions																					
Total Greenhouse Gases (CO2 Equivalents) [9]	305.0	10,799.0		84.1	11,626.7	22,814.7	305.0	10,799.0		47.3	2,207.1	(977.2)	7.8	12,388.9	157.7	31.7	6.7	33.0		2,605.0	2,834.1
Net Greenhouse Gases (CO2 Equivalents) [10]	305.0	2,872.0		84.1	11,152.0	14,413.1	305.0	2,872.0		47.3	5.3	(981.9)	7.8	2,255.4	157.7	31.7	6.7	33.0		2,605.0	2,834.1
Nitrogen Oxides	3.7	14.4		1.0		19.1	3.7	14.4		0.57	1.8	(4.5)	0.10	16.2	1.9	0.17	0.08	0.28		9.9	12.4
Particulates	0.8	11.3		0.23		12.3	0.8	11.3		0.13	0.27	(3.2)	0.02	9.3	0.4	0.11	0.02	0.05		6.0	6.6
Sulfur Oxides	0.5	26.9		0.14		27.6	0.52	26.9		0.08	0.39	(8.4)	0.01	19.5	0.3	0.29	0.01	0.06		20.0	20.6
Hazardous Air Pollutants (HAPs)[8]		2.4				2.4		2.4						2.4						0.030	0.030
Volatile Organic Chemicals (VOCs)[8]		5.7				5.7		5.7						5.7						1.6	1.6
Total Reduced Sulfur (TRS)[8]		0.37				0.4		0.37						0.4						0.0	0.0
Solid Wastes	1.0	382.0	193.6	0.26	2,000.0	2,576.8	1.0	382.0	193.6	0.15	248.4	(117.0)	0.02	708.1	0.49	163.8	0.02	0.10	205.6	209.8	579.8
Waterborne Wastes																					
Biochemical Oxygen Demand (BOD)	0.0013	6.1	0.0011	0.0003		6.1	0.0013	6.1	0.0011	0.0002		(0.0007)	0.0001	6.1	0.0006	0.0002	0.0000	0.0002	0.0011	2.1	2.1
Chemical Oxygen Demand (COD)	0.0051	81.0	0.0032	0.0016		81.0	0.0051	81.0	0.0032	0.0008		(0.0019)	0.0001	81.0	0.0030	0.0005	0.0001	0.0006	0.0034	5.0	5.0
Suspended Solids	0.0013	9.8	0.0021	0.0003		9.8	0.0013	9.8	0.0021	0.0002		0.000	0.0000	9.8	0.0006	0.0000	0.0000	0.0002	0.0022	1.7	1.7
Effluent Flow (gals/ton)[8]		20,500				20,500		20,500						20,500						1,927	1,927

NOTES:
(1) Landfill gas collected for energy recovery not included.
Only carbon dioxide and methane in landfill are gas included in atmospheric emissions; methane has been converted to carbon dioxide equivalents using a molecular ratio of 25:1 and a weight ratio of 69:1.
Waterborne wastes caused by leachate from landfills not included.
(2) Air emissions based on new source performances standards (NSPS) for combustors > 250 tpd.
(3) Values in parentheses represent energy and environmental releases from a utility avoided due to energy generation by incineration.
Assumes 642 kwh of electricity generated by a utility is avoided by combusting one ton of material.
Avoided releases based on fuel mix for national electricity energy grid.
(4) Waterborne wastes caused by leachate from ash landfills not included.
Assumes burning yields 13 percent ash residue by dry weight, 25 percent moisture content as disposed.
(5) Assumes curbside collection of material.
(6) Assumes material is processed at a material recovery facility (MRF); values based on average of low tech and high tech MRF.
(7) Values represent the solid waste and waterborne wastes associated with utility generation of electricity purchased
by the virgin or recycled pulp and paper mill; energy and air emissions have been incorporated into the adjacent manufacturing energy/releases column.
Releases incurred or avoided are based on fuel mix for national electricity energy grid.
(8) Values for this parameter are reported by the cited sources only for the virgin and recycled manufacturing processes.
(9) Total greenhouse gases include CO2 emissions from combustion of both wood-derived materials (including paper) and fossil fuels as well as CO2 and methane emissions from landfills.
(10) Net greenhouse gases include CO2 emissions from combustion of fossil fuels and methane emissions from landfills; see text for full explanation.

SOURCES:

(1) VIRGIN PRODUCTION + LANDFILLING:
Column a: PTF calculations based on Franklin Associates, 1994 (for fuel-related release factors) and Argonne, 1993 (for energy use estimates).
Column b: PTF calculations (detailed in White Paper 10C), based on sources provided therein.
Column c: Franklin Associates, 1994 and PTF calculations (detailed in White Paper 10C), based on sources cited therein.
Columns d-e: Franklin Associates, 1994, with adjustments made to greenhouse gas data in column e as explained in Note 1 and White Paper 3.

(2) VIRGIN PRODUCTION + INCINERATION:
Column a: PTF calculations based on Franklin Associates, 1994 (for fuel-related release factors) and Argonne, 1993 (for energy use estimates).
Column b: PTF calculations (detailed in White Paper 10C), based on sources provided therein.
Column c: Franklin Associates, 1994 and PTF calculations (detailed in White Paper 10C), based on sources cited therein.
Columns d-g: Franklin Associates, 1994, with adjustments made to columns d-f as explained in White Paper 3.

(3) RECYCLED PRODUCTION + RECYCLING:
Columns a-d: Franklin Associates, 1994.
Column e: Franklin Associates and PTF calculations (detailed in White Paper 10C), based on sources cited therein.
Column f: PTF calculations (detailed in White Paper 10C), based on sources provided therein.

ENDNOTES

[1] Jaakko Pöyry Consulting, *Market Potential for Office Wastepaper in the Northeast*, Prepared for the Council of States Governments Eastern Regional Conference and the Northeast Recycling Council, September 21, 1991.

[2] Resource Information Systems, Inc., *RISI Long-Term Pulp and Paper Review*, Bedford, MA: RISI, July, 1995, p. 240.

[3] Franklin Associates, Ltd., *Evaluation of Proposed New Recycled Paper Standards and Definitions*, Washington, DC: Recycling Advisory Council, 1991, Table A-2. (The table provides a projection for 1995).

[4] Franklin Associates, *Characterization of Municipal Solid Waste in the United States*, 1994 Update, prepared for U.S. Environmental Protection Agency, Municipal and Industrial Solid Waste Division, Washington, DC, Report No. EPA/530-S-94-042, November 1994.

[5] American Forest & Paper Association, *1995 Annual Statistical Summary, Recovered Paper Utilization*, Washington, DC; AF&PA, April 1995, p. 81.

[6] The "recovery rate," or collection of used paper for recycling, is a slight overestimate, because it divides collected bales of recovered paper (which include additional moisture and contaminants) by new production plus net imports (which are clean and drier). Paper that is imported into the United States in the form of packaging for finished products is not counted in the base of paper available for recycling. Likewise, the "utilization rate" of recovered fiber by U.S. paper mills is not the same as average industry-wide recycled content, because some recovered fiber and contaminants in recovered paper used by mills becomes a manufacturing process residue rather than new product.

[7] American Forest & Paper Association, *1995 Annual Statistical Summary, Recovered Paper Utilization*, Washington, DC; AF&PA, April 1995, p. 81.

[8] Estimate provided by the American Forest & Paper Association, based on projections of recovered paper use from 1993-2000 (AF&PA projection) and the average capital cost per ton of capacity (RISI estimate), August 29, 1995.

[9] "Analysts Expect Rebound in Wastepaper to Continue Through 1995 and Beyond", *Paper Recycler*, January 2, 1995, pp. 1-8.

[10] When recovered paper prices are within their historical range, recycling-based manufacturing is generally less costly than virgin pulp and paper manufacturing for the grades of paper that have traditionally contained some recycled content (commercial-grade tissue, corrugating medium, linerboard, 100% recycled paperboard and newsprint in some cases). As technology evolves and as opportunities arise to fit deinking plants into incremental expansions of capacity for printing and writing paper, recycling is becoming a viable option for manufacturers of printing and writing paper as well. See Paper Task Force White Paper No. 2, *Economics of Recycling as an Alternative to Traditional Means of Solid Waste Management* and White Paper No. 9, *Economics of Manufacturing Virgin and Recycled-Content Paper*.

[11] Virgin pulping systems can also be expanded incrementally in some cases, but tend to reach certain basic limits determined by equipment such as recovery boilers, as discussed in Chapter 5.

[12] American Forest & Paper Association, *Paper, Paperboard & Wood Pulp, 1995* Statistics, Washington, DC: AF&PA, September, 1995, p. 56.

[13] Based on personal communications with George Brabeck, Weyerhaeuser, Chicago, IL; Ann Tennes, Solid Waste Agency of Cook County, IL. November 2, 1995. For more information, contact Ann Tennes, Solid Waste Agency of Cook County, 1616 East Golf Road, Des Plaines, IL, 60016. See also, Steve Aptheker, "Making the Big Jump in Commercial Recycling, One Small Business at a Time," *Resource Recycling*, November, 1995, pp. 16-26.

[14] Contact Dana Draper, executive director, Northeast Resource Recovery Association, P.O. Box 721, Concord, NH, 03302; (609) 224-6996.

[15] Federal Register 49992, October 2, 1991.

[16] The designation of over-issue materials in the preconsumer category is contained in the Resource Conservation and Recovery Act (RCRA), section 6002 (e).

[17] Federal Register 49992, October 2, 1991.

[18] The formula for measuring the recycled content of paper as a percentage of total fiber weight is: (Recovered paper x yield)÷[(virgin pulp x yield) + (recovered paper x yield)]= % recycled fiber content.

[19] See White Paper No. 9 for a list of deinked market pulp mills operating, under construction or financed in the United States.

[20] Estimates based on data from the Canadian Pulp and Paper Association, "Recycled Content Newsprint Capacity; North America," Montreal: CPPA, January, 1995 and Resource Information Systems, Inc., *RISI Long Term Paper Review*, Bedford, MA: RISI, July, 1995, pp. 69, 77.

[21] "Chicago Board of Trade Recyclables Exchange Project Overview," CBOT, September, 1995.

[22] "The Recycled Paper Coalition," statement, August 15, 1994.

[23] Recycled Paper Coalition, *1994 Annual Report*, May 15, 1995, p. 5.

[24] RCRA section 6002(e) as amended by the Hazardous and Solid Waste Amendments of 1984 required the U.S. EPA to issue a "procurement guideline" for paper. Section 6002(c) requires federal purchasing agencies to buy paper products containing the "highest levels of postconsumer materials practicable," as long as the products meet reasonable performance standards, are reasonably available, and reasonably priced. The EPA's guideline can be found in 40 CFR Part 250, 53 Federal Register 23546, June 22, 1988.

[25] In the United States, landfilling is used to manage about 80% of the MSW that is not recycled, while waste-to-energy incineration manages virtually all of the remaining 20%. See Franklin Associates, *Characterization of Municipal Solid Waste in the United States, 1994 Update*, prepared for U.S. Environmental Protection Agency, Municipal and Industrial Solid Waste Division, Washington, DC, Report No. EPA/530-S-94-042, November 1994. This 4-to-1 ratio was applied to the landfill- and incinerator-specific data developed in our analysis in order to estimate energy use and environmental releases associated with disposal of used paper as part of MSW.

[26] Other activities involved in growing trees that may result in net emissions of CO_2 are not included here. Examples of such activities are soil disturbance associated with preparing a site for tree planting and energy or materials used in the production of fertilizers used in forests.

[27] Franklin Associates, Ltd., *The Role of Recycling in Integrated Waste Management to the Year 2000*, prepared for Keep America Beautiful, Inc., September 1994, Appendix I, p. 8.

[28] In Figures 2 and 6-9, the comparison shown is between the *recycled production plus recycling* system and the *virgin production plus waste management* system. The latter system represents a weighted average of the *virgin production plus landfilling* and *virgin production plus incineration* systems shown in the tables; these systems have been weighted on the basis of national estimates for the relative use of MSW landfilling (used for 79.7% of discarded paper, after recycling) and MSW waste-to-energy incineration (used for 20.3% of discarded paper, after recycling). Franklin Associates, *Characterization of Municipal Solid Waste in the United States*, 1994 Update, prepared for U.S. Environmental Protection Agency, Municipal and Industrial Solid Waste Division, Washington, DC, Report No. EPA/530-S-94-042, November 1994.

[29] Because of greater availability of data, our quantitative comparison is based on collection of recovered paper through residential curbside collection programs. We recognize that other types of systems (e.g., drop-off centers and collection from commercial sources) represent the majority of total paper recovery. This assumption of curbside collection overstates the energy use and associated environmental releases associated with collection of paper, especially for grades such as old corrugated containers and office paper that are collected largely from commercial sources through more efficient systems.

Similarly, our analysis includes processing of recovered paper at material recovery facilities (MRFs). Because some recovered paper, especially that from commercial sources, bypasses such intermediate processing and can be delivered directly to the mill, this assumption too probably overstates energy use associated with the recycling option.

[30] Bill Moore, "How Recycling is Changing the Structure of the Pulp and Paper Industry," *Resource Recycling*, September, 1994, p. 83-86.

[31] *Solid Waste Digest*, Northeast, Southern and Western editions, December, 1994, p. ii (each edition). William Ferretti, director, Office of Recycling Market Development, New York State Department of Economic Development, letter, May 12, 1995.

[32] The survey also counted 3,202 facilities for composting yard trimmings. Robert Steuteville, "The State of Garbage in

America: BioCycle Nationwide Survey," *BioCycle*, April 1995, pp. 54-63.

[33] Efficiencies can be gained by redesigning collection trucks so they can pick up trash and recyclable materials at the same time, or greater quantities of recyclable materials than earlier generation trucks. Changes in collection scheduling and routing, in home and commercial source separations systems and in paper processing equipment, can also help lower net costs.

[34] For insights on the cost of recycling based on actual data from surveys of U.S. cities, see: Barbara Stevens, "Curbside Collection by the Numbers: Results of a National Survey," *Resource Recycling*, August 1994. Barbara Stevens, "The Cost of Commercial Recycling Collection," *Resource Recycling*, December, 1994, pp. 36-40. Barbara Stevens, "Lessons from High Achievers: Cities with Successful Curbside Recycling Programs," *Resource Recycling*, October, 1995, pp. 58-63.

[35] Steve Apotheker, "Curbside Recycling: The Second Generation," *Resource Recycling*, April, 1995, pp. 38-50.

[36] Paper Task Force White Paper No. 2.

[37] Ontario Multi-Materials Recycling, Inc., *Markets Report: Appendix C, Recycling Contract Review: Interim Report*, Toronto: Resource Integration Systems, Inc.

[38] For example, "One informal survey of 66 communities in the Minneapolis-St. Paul area found that 90 percent did not have contracts that allowed them to share in market revenues." The missed revenue adds up to $13 million per year, or $24 per household. Steve Apotheker, "Ask and You Shall Receive, but Many Communities Don't," *Resource Recycling*, September, 1995, pp. 21- 26. The article includes suggestions for revenue-sharing contracts with recycling collection companies.

[39] Analysis in White Paper No. 9.

[40] For the "low" price scenario, we used the lowest U.S. average price for a specific grade of recovered paper that occurred in the 1991-1993 period. For the "high" price scenario, we used U.S. average prices for specific grades as of June 1995. For the middle of the range, the Task Force used projected "trend" price estimates provided by Jaakko Pöyry Consulting, Inc., November 1995.

[41] The Jaakko Pöyry trend price estimates are based on an analysis of several factors: new capacity coming on-line (affecting the balance of supply and demand), the price that mills can afford to pay in the long term, increased collection of recovered paper in response to high prices and fiber shifting within the paper industry (makers of lower-value recycled paper products shifting to lower-cost recovered paper furnishes). The trend prices also reflect expectations of aggressive action by mills and recycling collectors to expand the collection infrastructure. These projections are similar to those made by other experts in the field, such as Franklin Associates and Thompson-Avant, Inc. *Paper Recycler*, January, 1995. Mary Cesar, senior consultant, Jaakko Pöyry Consulting, personal communication, April 14, 1995.

[42] Resource Information Systems, Inc., *RISI Long-Term Pulp and Paper Review*, Bedford, MA: RISI, July, 1995, pp. 208, 215.

[43] Haynes R.W. *et al*. *The 1993 RPA Timber Assessment Update*, USDA Forest Service, General Technical Report RM-259, Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, March 1995.

[44] Resource Information Services, Inc., *RISI Pulp & Paper Review*, Bedford, MA: RISI, April, 1995, p. 209.

[45] Jaakko Pöyry, 1994 *Global Fiber Resources Situation: "The Challenges for the 1990s*," presentation distributed by Jaakko Pöyry Consulting, Tarrytown, NY, October 1994.

[46] American Forest & Paper Association *Paper, Paperboard & Wood Pulp*, Washington, DC: AF&PA, September, 1995, p. 33.

[47] American Forest & Paper Association, *1995 Statistics: Paper, Paperboard & Wood Pulp*, Washington, DC: AF&PA, September, 1995, p. 33.

[48] Containerboard market awash in production as new capacity ramps up better than expected," *Pulp & Paper Week*, October 9, 1995, pp. 1-3.

[49] American Paper Institute, *Paper, Paperboard, Wood Pulp Capacity*; *1989-1993*, New York: API, 1990, p. 27.

[50] "Staying Competitive with Virgin is Now Long-Term Strategy for Deinked Pulp," *Paper Recycler*, June, 1995, pp. 1-6.

[51] Peter Ince, *Recycling and Long-Range Timber Outlook*, U.S. Forest Service, General Technical Report RM-2, February 1994, p. 21.

[52] In 1994, apparent world consumption of paper was 269.59 million tons; apparent U.S. consumption was 88.79 million

tons, or 32.9% — almost one-third. Resource Information Systems, Inc., *RISI Pulp & Paper Review*, April 1995, p. 221. The recovery rate in the United States in 1994 was 40% (AF&PA), meaning that 60% of all paper was not recovered. 60% of 32.9% is 19.7%.

53 This level of increase is consistent with the American Forest & Paper Association's goal of 50% paper recovery in the year 2000, compared to 40% recovery in 1994. Both of these figures include preconsumer paper scrap; the potential for postconsumer recovery is higher on a percentage basis (relatively more is still being disposed).

54 Non-fiber materials made up the difference between virgin and recycled fiber use and total paper production. Consumption of recovered paper does not equate to recycled content due to losses of some fiber in processing. RISI *Pulp & Paper Yearbook*, RISI *Pulp & Paper Review*.

55 American Forest & Paper Association, *1995 Statistics: Paper, Paperboard and Wood Pulp*, Washington, DC: AF&PA, September 1995, pp. 11, 31.

56 We have assumed here that 78% (by weight) of a sheet of printing and writing paper is comprised of fiber, the remainder being fillers, coatings and moisture (see White Paper No. 10A). Hence producing 1 ton of paper requires 0.78 tons of processed fiber per ton of paper ÷ 0.50 tons of unprocessed fiber per ton of trees ÷ 0.45 tons of processed fiber per ton of unprocessed fiber = 3.47 tons of trees.

57 The mill utilization rate for recovered paper was 6.2% in 1989. The mill utilization rate is higher than the average recycled content, measured by fiber weight, due to the loss of contaminants and fillers in the deinking process and the fact that recycled content is measured by fiber weight, not the total weight of the paper. American Forest & Paper Association, *1994 Annual Statistical Summary: Recovered Paper Utilization*, Washington, DC; AF&PA, May 1994, pp. 11, 12, 89.

58 Based on lists of U.S. paper mills developed in White Paper No. 9.

59 Interviews and written comments by representatives of Xerox Corporation, March 10, 1994, and June 7, 1995; of Copytex, September 15, 1994. See also Paper Task Force White Papers No. 1 and 8.

60 See White Paper No. 9 for a full analysis.

61 In some cases, such as 100% recycled paperboard, manufacturing costs using recycled fiber are lower than the virgin competition, even with high recovered-paper prices. In general, prices for finished paper products have risen, so that percentage profit margins have held the same or even increased, despite the rise in recovered-paper prices. Some 100% recycled-paper producers have sunk investments in recycling technology, so their use of recovered paper is not discretionary, unlike printing and writing paper mills using deinked market pulp. Producers are also selling finished products (boxes and cartons) in mature markets where there are a wide range of products with different levels of recycled content and substantial competition.

62 Paper Task Force White Paper No. 9.

63 "Price Watch," *Pulp & Paper Week*, October 6, 1995, p. 6. Steve Semenchuck, SRFI, personal communication, November 2, 1995.

64 See White Paper No. 9.

65 See Paper Task Force White Paper No. 9 for a more detailed quantitative analysis.

66 Mills utilizing existing equipment in their recycling systems include Fraser Paper Ltd. in Madawaska, ME, Boise Cascade Corp. in Vancouver, WA and Westvaco Corp. in Tyrone, PA. Mills based on a 100% deinked production that have upgraded their systems include P.H. Glatfelter Co. in Neenah, WI, Cross Pointe Paper Co. in Miami, OH, and Georgia-Pacific Corp. in Kalamazoo, MI.

67 Union Camp in Franklin, VA.

68 Daniel Mulligan, "Finding an Economic Alternative from Outside the Paper Industry for Processing Recovered Paper Materials," presented at Wastepaper VI Conference, Chicago, IL, May 9-12, 1995.

69 Boise Cascade at Jackson, AL and International Paper at Selma, AL.

70 Paper Task Force, White Paper No. 9.

71 The paper industry sometimes uses a more complex classification. "Semi-commodity" papers include carbonless, book, ledger, map, cigarette and greeting card papers. "Semi-specialty" papers include electrical, coffee filter, currency and fine stationary papers. "Specialty" papers include teabag, gasket, air/liquid filter and medical papers. "Specialty Paper; Heading for Uncharted Waters," *Pima Magazine*, October, 1995, pp. 34-36.

[72] Westvaco in Tyrone, PA and International Paper in Corinth, NY. The latter mill makes both coated groundwood and freesheet papers, but is converting to primarily freesheet grades.

[73] In 1995, Consolidated Papers purchased the Superior Recycled Fiber Industries' (SRFI) deinked market pulp mill in Duluth, MN along with two paper mills from Pentair, Inc. Repap purchased the relatively small Refibre deinked-market pulp mill in Appleton, WI, which sends the majority of its output to Repap's coated paper mill in Kimberly, WI.

[74] Fraser Paper Ltd. in Madawaska, ME and Haindl Papier GmbH in Walsum, Germany manufacture coated groundwood paper using deinked pulp obtained from newspapers and magazines. Bowater, Inc. in East Millinocket, ME and United Paper Mills Ltd. (Yhtyneet Paperitehtaat Oy) in Kaipola, Finland operate mills that primarily manufacture recycled-content newsprint but also have the capacity to used deinked mechanical fiber in coated papers.

[75] Champion International at Shelton, TX, *Pulp and Paper Project Report*, November, 1995.

[76] The term "containerboard" includes chip and filler boards, which are mainly used as internal partitions and for other industrial uses, as well as linerboard and corrugating medium, but these are comparatively minor uses and are not covered in this report.

[77] American Forest & Paper Association, *Paper, Paperboard and Wood Pulp - 1995 Statistics*, Washington, DC, September 1995, pp. 14-15.

[78] We have assumed here that 94% (by weight) of corrugated boxes is comprised of fiber, the remainder being moisture. The yield of unbleached kraft pulping to produce linerboard is assumed to be 57%, while that for semi-chemical pulping used to produce corrugating medium is assumed to be 75%. Assuming that a corrugated box is 33% medium and 67% linerboard by weight, the average yield for the box is 63%. (See White Paper No. 10B.) Hence producing 1 ton of paper requires 0.94 tons of processed fiber per ton of paper ÷ 0.50 tons of unprocessed fiber per ton of trees ÷ 0.63 tons of processed fiber per ton of unprocessed fiber = 2.98 tons of trees.

[79] Data from Jacob-Sirrine Consultants reported by the American Forest & Paper Association's comments on Paper Task Force White Paper No. 6A, *Functionality Issues for Corrugated Packaging Associated with Recycled Content, Source Reduction and Recyclability*.

[80] Paper Task Force White Paper No. 9.

[81] Paper Task Force White Paper No. 6A.

[82] Franklin Associates, Ltd., *Evaluation of Proposed New Recycled Paper Standards and Definitions*, Washington, DC: Recycling Advisory Council, 1991, Table A-2. (The table provides a projection for 1995).

[83] Paper Task Force White Paper No. 6A.

[84] Paper Task Force White Paper No. 9 analysis.

[85] Vivian Toy, "Paper Recycler will Build Plant on S.I.," *New York Times*, August 2, 1995, p. 132.

[86] David Null, Economics of Mini-Mills vs. Large-Scale Kraft Linerboard Mills," Sixth International Containerboard Conference, New York, NY September 16-18, 1994.

[87] For example, International Paper converted it's Oswego, NY printing and writing paper mill to 100% recycled linerboard production, Bay State Paper in Hyde Park, MA converted a printing and writing paper mill to make 100% recycled corrugating medium. Stone Container is converting a linerboard machine and a newsprint machine in Snowflake, AZ to make 100% recycled corrugating medium. *Pulp & Paper Project Report*, June 30, 1995, pp. 1-3.

[88] Franklin Associates, Ltd., *The Role of Recycling in Integrated Waste Management to the Year 2000*, prepared for Keep America Beautiful, Inc., September 1994, Table 2-4, pp. 2-12.

[89] Howard Ingram, Vice President, Paper Recycling International, personal communication, October 14, 1994.

[90] "Pratt to build 'milligators' across the U.S. to supply independent converters," *Pulp & Paper Week*, October 2, 1995, pp. 1-5.

[91] U.S. Environmental Protection Agency, *Characterization of Municipal Solid Waste in the United States: 1994 Update*, EPA 530-S-94-042, November 1994, pp. 67, 69 and 70.

[92] The Franklin Associates numbers also include an estimate of the amount of corrugated packaging that arrives in the United States as secondary packaging for other imported goods, which AF&PA does not consider.

[93] American Forest & Paper Association, *1993 Recovered Paper Statistical Highlights*, Washington, DC: AF&PA, 1994, p. 16.

94 Franklin Associates, Ltd., *The Outlook for Paper Recovery to the Year 2000*, prepared for the American Forest & Paper Association, November 1993; Fred Iannazzi and Richard Strauss, "OCC: Prices to Rise as Supply Falls Short of Demand," *Pulp & Paper International*, November 1994, pp. 46-47; and personal communication with Fred Iannazzi, Andover International Associates.

95 Contact Terry Serie, American Forest & Paper Association, 1111 19th St., NW Suite 800, Washington, DC, 20036, (202) 463-2700.

96 Joseph Hanlon, *Handbook of Package Engineering*, 2nd Edition, Lancaster: Technomic Publishing Co., 1992, p. 6-2.

97 The abbreviations for "coated natural kraft" (CNK) and "solid unbleached sulfate" (SUS) are registered trademarks of Mead Corp. and Riverwood International, respectively, the only two producers of this grade.

98 American Paper Institute, *The Dictionary of Paper*, New York: API, 1980; "Paperboard: Steady Growth Expected," *Pulp & Paper*, January, 1990; and Peter Bunten, American Forest & Paper Association, personal communication, January, 1995.

99 Paperboard production reported in the folding carton category also includes packaging such as blister packs and record jackets. American Forest & Paper Association, *1995 Statistics: Paper, Paperboard and Wood Pulp*, Washington, DC: AF&PA, September, 1995, p. 13.

100 *1994 Pulp & Paper Factbook*, San Francisco: Miller Freeman, 1994.

101 American Forest & Paper Association, *1995 Statistics: Paper, Paperboard and Wood Pulp*, Washington, DC: AF&PA, September, 1995, p. 22, 26.

102 As in the case of corrugated boxes, CUK folding cartons were assumed to be 94% fiber by weight, and the yield of the process for making CUK folding cartons — which, like corrugated linerboard, are unbleached — was also assumed to be 57%. Hence producing 1 ton of paper requires 0.94 tons of processed fiber per ton of paper ÷ 0.50 tons of unprocessed fiber per ton of trees ÷ 0.57 tons of processed fiber per ton of unprocessed fiber = 3.30 tons of trees. As in the case of bleached printing and writing papers, SBS folding cartons were assumed to be 78% fiber, and the yield of the process for making SBS folding cartons — which are bleached — was assumed to be 45%. Hence producing 1 ton of paper requires 0.78 tons of processed fiber per ton of paper ÷ 0.50 tons of unprocessed fiber per ton of trees ÷ 0.45 tons of processed fiber per ton of unprocessed fiber = 3.47 tons of trees.

103 *1994 Pulp & Paper Factbook*, San Francisco: Miller Freeman, 1994, p. 278.

104 Leo Mulcahey, Bleached Board Division, Westvaco, personal communication, March 13, 1995.

105 It should be noted that paperboard for folding cartons is sold on an area basis (dollars per 1000 square feet), rather than a weight basis. Resource Information Systems, Inc., *Paper Packaging Monitor*, New Bedford, MA: RISI, March 1995, p. 4.

106 Data provided by Resource Information Systems, Inc., 1995.

107 Charles Spencer and Matt Berler, "Paper and Packaging: Surpassing the Cost Curve in 1995," Morgan Stanley U.S. Investment Research, February 24, 1995, p. 1.

108 These data are for 20-pt. clay-coated recycled paperboard produced at northern U.S. mills. Resource Information Systems, Inc., *Pulp and Paper Review*, New Bedford, MA: RISI, April 1995.

109 These communities include Seattle, WA, DuPage County, IL, St. Paul, MN, Santa Monica, CA, and numerous towns and cities in New Jersey.

110 Loreen Ferguson, "RN: The Effects on Fibres of Multiple Recycles," *1993 Recycling Symposium*, Atlanta, GA: Technical Association for the Pulp and Paper Industry, 1993, pp. 215-229. Mousa Nazhad and Laszlo Paszner, "Fundamentals of Strength Loss in Recycled Paper," *Tappi Journal*, September, 1994, pp. 171-179.

111 Barbara Crowell, "Increased Utilization of Recycled Fibers: Impact on Corrugated Board Performance," presented at PACK3 conference, Brussels, Belgium, May 3-4, 1993.

112 American Forest & Paper Association, "Graphic Evidence, Progress in Printing-Writing Paper Recovery and Recycling," November, 1994.

4 FOREST MANAGEMENT

I
Introduction

II
Recommendations for purchasing paper products made from fiber acquired through environmentally preferable forest management practices

III
Purchaser implementation options

IV
Environmental and economic findings

V
Answers to frequently asked questions

FOREST MANAGEMENT[1]

This chapter and the Paper Task Force recommendations on forest management are intended to:

- Enhance the awareness and knowledge of purchasers and users of paper, by providing clear information on the consequences of forest management practices used to produce paper products.
- Formulate a number of straightforward actions that purchasers can take, to demonstrate their desire for environmentally preferable forest management to their existing and prospective suppliers of paper products, thereby recognizing existing sound management practices and helping to spur needed changes.
- Provide specific performance measures purchasers can use in evaluating and comparing their suppliers' practices that will allow them to make environmental considerations associated with forest management an explicit purchasing criterion, to be considered alongside more traditional criteria such as cost and product performance.

I. INTRODUCTION

This chapter presents the Paper Task Force's recommendations and implementation options for advancing environmentally preferable forest management practices in the production of pulpwood used to make paper and paperboard products. It also provides a summary of the supporting rationale for the recommendations, including the key findings from the Task Force's extensive research on both environmental and economic aspects of forest management.

The remainder of this section provides the reader with important background information and a context for understanding the Task Force's recommendations, findings and rationale for the recommendations. This section also includes an overview of the activities that together comprise forest management. Section II presents the Task Force's recommendations, along with a summary of the supporting rationale. Section III presents implementation options for purchasers seeking to take action on the Task Force's recommendations. Section IV presents the Task Force's findings on environmental and economic aspects of forest management. These findings are taken directly from the Task Force's primary research documents on forest management – White Papers Nos. 4 and 11 – which are contained in Volume II of this report and provide the full rationale and documentation for the findings. Finally, Section V provides answers to several frequently asked questions that purchasers may ask or be asked.

How Is Forest Management Relevant to Paper Purchasers?

To most purchasers and users of paper, at least until very recently, forest management has appeared far removed from their vocation, even to those who are generally aware of and concerned about environmental issues associated with paper. Such concerns have typically found their expression among purchasers in debates or decisions about the recycled content of paper or about whether and how to recycle it, or, more recently, about certain aspects of how the paper was manufactured. The prominent public discourse that has been swirling about such topics as clearcutting, old-growth forests, and spotted owls and red-cockaded woodpeckers may seem of only more general interest or concern, quite removed from day-to-day decisions about what type of paper to buy or how to manage it after use.

For several reasons, however, such issues are in fact directly relevant to purchasers and users of paper who seek a full understanding of the environmental consequences of their decisions concerning the paper they buy and use. First, understanding the environmental differences between virgin and recycled-paper production, use and post-use management requires assembling a complete picture. This means not only examining differences in recycled and virgin manufacturing processes and in waste disposal vs. material recovery systems, but also considering the "upstream" impacts associated with acquiring virgin fiber from forests.[2]

Second, no matter how much recycling is done, a large fraction of paper and paper products will continue to be made using virgin fiber acquired from forests. For this virgin fiber, the relevance of forest management practices to paper purchasing is quite direct: environmental impacts (positive or adverse) arising from such practices can be attributed to the resulting fiber, and hence to pulp and paper products made using such fiber. Just as purchasers may care about and want to better understand — and may seek to use their purchasing power to influence — the manner in which the paper products they use are made or managed after use, so too with how that virgin fiber is acquired.

In the largest sense, purchasers and users of paper bear a share of the responsibility for environmental impacts arising from *all* of the activities required to produce and manage this material. Just as with impacts from manufacturing and used paper management, forest management for fiber production — whether on public or private lands — can impinge on a range of public goods and values, including water quality, wildlife habitat, preservation of natural forest ecosystems and conservation of biodiversity. The Paper Task Force believes that implementing these recommendations provides a way that purchasers can both proactively acknowledge their responsibility and, through their purchases, promote the use of environmentally preferable forest management practices. In this way, purchasers also will be responding to the concerns of a growing segment of their customers, who understand and are increasingly outspoken about the link between paper and forests.

In many cases, it is difficult or impossible to isolate forest management for purposes of fiber production from that associated with production of solid wood products. While fiber used in pulp and paper manufacture may be derived directly from trees grown for pulpwood, it often comes indirectly from trees grown mainly for solid wood products. Even in such cases, significant amounts of pulpwood are produced. Typically, forest managers intentionally plant a higher density of trees than is ultimately desired at final harvest; the excess trees are thinned in the middle of the life of a stand of trees and sold as pulpwood. In addition, some of the trees cut at final harvest will not be suitable for use in solid wood products, and are again used as pulpwood. Finally, logging and sawmill residues from the production of lumber also constitute a significant source of pulpwood. Revenue from all these sources of pulpwood production is a significant contributor to the overall economics of forest management, even where solid wood is the primary product.

Methodology and Scope of the Task Force's Work on Forest Management

The Task Force conducted extensive research on forest management, including a thorough review of published articles and papers on environmental and economic dimensions of forest management, a review of existing regulatory and voluntary methods of mitigating environmental impacts, and information gathered from Task Force technical visits, presentations to the Task Force by experts, and other interviews with experts. As an additional step in the research process, the Task Force assembled a panel of experts from several sectors to discuss the issues associated with forest management for solid wood or fiber production. Panelists discussed an issue paper that had been prepared by the Task Force, which laid out the relevant environmental issues surrounding forest management, as well as the range of perspectives and opinion on those issues held by various stakeholders. The issue paper was also reviewed by several other outside experts. The Task Force then drafted two technical White Papers covering environmental and economic aspects of forest management. These papers were subject to extensive expert review and revised based on the comments received. The findings from these White Papers are presented later in this chapter. Finally, the Task Force conducted a series of meetings with several organizations to discuss the implications of the findings for our recommendations on forest management.

The scope of the Task Force's research encompassed the following issues:

General topics

- The context of pulpwood production in the forested landscape, including land ownership patterns, the variation in landowner objectives and areas of intensive production in relation to environmentally significant parts of the landscape.
- Existing efforts and methods to control or mitigate the potential adverse environmental impacts from forest management, including federal laws, state guidelines and voluntary efforts.

Environmental topics

- The range of potential impacts of forest management on forest soils, water, plants and animals.
- The potential impacts of forest management (in particular, intensive plantation management) on rare or dwindling natural forest communities.
- The potential effects of certain high-profile management activities that deserve particular attention because of their prominence in public debate, including clearcutting and artificial regeneration (examined in relation to other harvesting/regeneration methods).

Economic topics

- Overall timber and pulpwood supply and demand, including future projections.
- The effect of increased paper recycling on pulpwood supply and demand, and on its price.
- Past, present and future projections of pulpwood prices.
- The cost structure of pulpwood production.
- The economic ramifications of changes in forest management practices that might be environmentally preferable.
- Broader economic costs and benefits associated with how forests are managed for wood production.

Forest Management in Broad Context

Two points need to be kept in mind in considering the potential environmental impacts of forest management. First, many or all of the environmental impacts discussed may also occur as a result of other land uses, and may be of significantly greater magnitude from those other land uses than from forestry operations.

As an example, forest management is a lesser overall contributor to water pollution than agriculture or urban development, as measured in the percentage of river and stream miles affected by human activity. Nonetheless, forestry activities as a whole are still a substantial cause of non-point source pollution, particularly of nutrients (for example, nitrogen and phosphorus) and suspended sediments. Forest management impacts are generally localized, but their effects can be significant where it is the dominant land use with potential to affect water quality (for example, parts of the southeastern coastal plain). Water-quality impacts from forest management also merit concern because of the sheer size of the forested land base and the importance of forested watersheds for values such as recreation, wildlife habitat, fisheries and drinking water protection.

Even heavily managed forests also provide a range of other important environmental values not found on agricultural lands or developed lands, such as wildlife habitat, recreation and carbon storage. The fact that forests provide these values underscores the need to protect natural forest values and to minimize adverse environmental impacts from forest management; it also acknowledges that, on any given area of land, silviculture is more likely than other land uses to protect and conserve these values. Because differently managed forests can vary greatly in the environmental values they provide, analysis of the relative environmental consequences of various management activities and systems is important.

The second point to be made about forest management is that the science and practice of silviculture has changed considerably over this century in response to changing public needs and concerns. For example, Best Management Practices (BMPs), state-level guidelines or requirements for protecting water quality during forestry activities, are now in place in all major timber-producing states. The development and implementation of BMPs represents a major step in acknowledging and reducing the adverse impacts of forest management on water quality, one of the most important and well-established environmental concerns.

More recently, in response to growing concern about environmental impacts on wildlife and forest ecosystems, the prevailing management paradigm has shifted from "sustained-yield forestry," which emphasized maintaining a constant flow of timber from the forest, to "sustainable forestry," which attempts to sustain all forest values, including non-timber values such as wildlife habitat and water quality. Related ideas have also emerged, such as "ecosystem management," which emphasizes managing whole forest landscapes rather than individual stands.

While such ideas have influenced management on public lands for some time, recent efforts to incorporate principles of sustainable forestry and ecosystem management in private timberland management have been undertaken — most notably the Sustainable Forestry Initiative announced in 1994 by the American Forest & Paper Association, a 1993 report on sustaining long-term forest health and productivity published by the Society of American Foresters, and the emergence of programs to certify the sustainability of forest management practices employed on private lands or the products produced through the use of such practices. These initiatives will be discussed below.

Overview of Forest Management Activities

A textbook definition of forestry might read as follows: *Forestry* is the art, science and practice of managing forested landscapes to provide sustained production of a variety of goods and services for society: jobs, timber products, fish and wildlife habitat, high quality of water and recreational opportunities, wilderness, range values, visually attractive landscapes and views, and so on. *Silviculture*, often thought to be synonymous, can be defined more narrowly to be the art and science of establishing, tending, protecting and harvesting a stand of trees.[3] While much of our discussion here of environmental impacts will focus on silvicultural practices, much of the debate over forest management issues centers on the degree to which silvicultural practices reflect or are consistent with the full range of values included in the definition of forestry just given.

Forest management for purposes of production of both solid wood and fiber entails two scales of activity. The first involves specific activities carried out on a specific *stand* of trees over the course of a specific time period, called a *rotation*. The second involves the spatial and temporal distribution of silvicultural activities across the entire area of forest being managed.

Two major types of silvicultural systems can be distinguished. *Even-aged management* involves stands where virtually all of the trees are of basically the same age, reflecting the fact that all the trees in the stand were harvested, and all of the trees in the new stand were established, at approximately the same time. *Uneven-aged management* involves harvesting and seedling-establishment activities that are spread both spatially and temporally over the stand, thereby resulting in a stand of trees covering a wide range of age and tree size.

In most even-aged silvicultural systems, activities conducted in a given stand over the course of a given rotation will include harvesting, site preparation, regeneration, stand tending and protection, and thinning; at the end of the rotation, the stand is harvested and the cycle begins again. Variants on some of these steps will also occur in an uneven-aged system. For each activity, a variety of methods may be used, depending on the character of the specific site, the range of values being managed for and the overall *intensity* of the management regime.

The prevailing paradigm has shifted from "sustained-yield forestry"—maintaining a constant flow of timber—to "sustainable forestry," which also attempts to sustain forest values such as wildlife habitat and water quality.

Forests can be intensively managed for any of a number of objectives, including wildlife habitat or recreation (e.g., hunting), as well as wood production. In this paper, we will generally use the term "intensity" in the context of wood production, where it generally relates to whether or not specific yield-enhancing practices are employed, or the extent to which they are employed. Intensity can be used to characterize the nature or extent of use of a particular practice, as well as the combination of practices that comprise the overall management system. For example, the intensity of harvesting is determined by how much

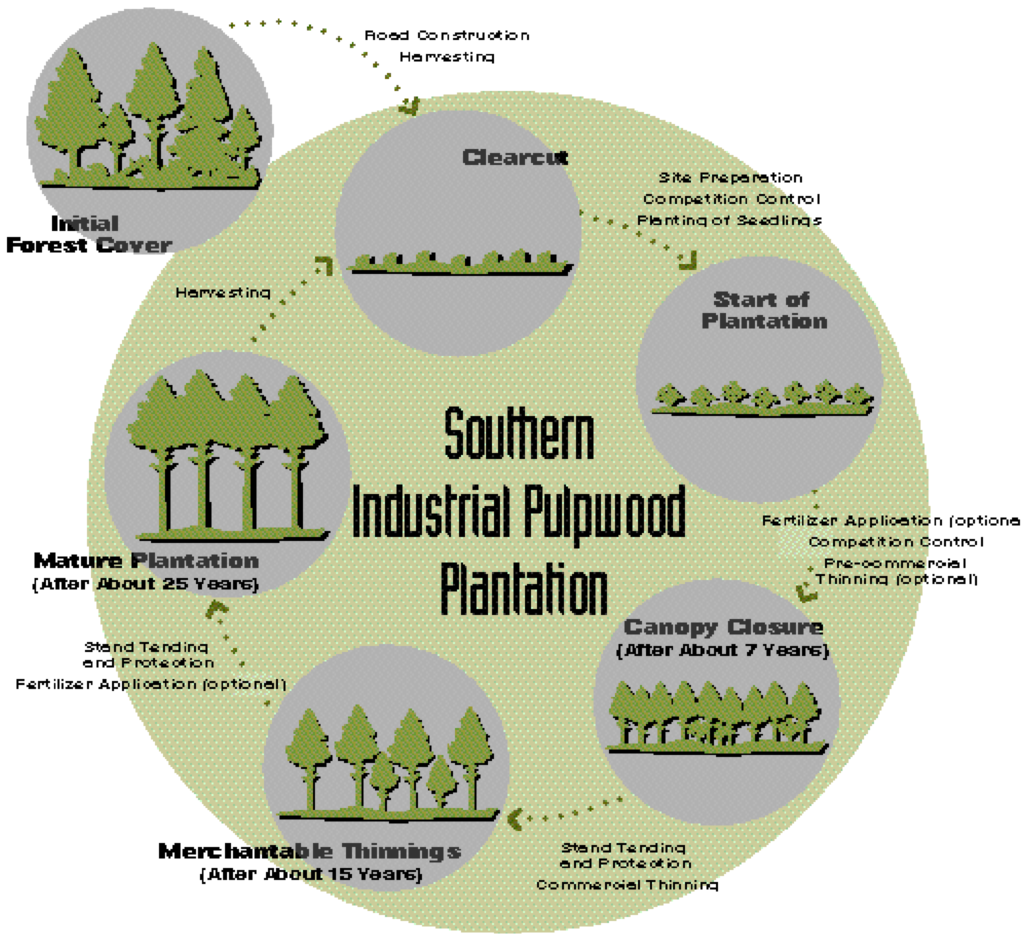


Figure 1

wood is removed at each harvest, and how frequently wood is removed. Similarly, site preparation methods following harvesting that involve removing most or all debris and applying herbicides are more intensive than those that leave debris in place. In practice, management intensity spans a spectrum from essentially unmanaged to highly intensive. At the latter end of the spectrum are softwood plantations which employ even-aged management and all or most of the practices described below. Natural forest management and uneven-aged management systems may also vary in intensity with respect to, for example, the frequency of entries and the extent of removal at each entry.

What follows is a brief description of the range of practices that may be employed in forest management, proceeding step by step through a typical management rotation. For purposes of organization, primary reference is given to even-aged systems. A typical southern pine plantation management regimen is illustrated in Figure 1.

1. Road Construction

Roads are essential for harvesting wood, and thus are among the most ubiquitous elements of forest management. Forest roads also provide access to the stand for other subsequent activities, such as site preparation, regeneration, stand-tending activities, thinnings and fire control. However, the construction, use and maintenance of forest roads potentially are significant sources of soil erosion and sedimentation in streams; they therefore deserve, and typically receive, special attention in logging plans.

2. Harvesting

The most visible step in even-aged silviculture, harvesting involves the logging of most or all of the trees in a stand. Although sometimes thought of as the culmination of forest management, harvesting is also the first step in even-aged silviculture: a site must be harvested before a new, managed stand is regenerated. Because the method of cutting helps to determine how the next stand regenerates, foresters generally refer to harvests as "regeneration cuts." For the purposes of this chapter, we will use the more familiar term "harvesting."

Harvesting methods vary with respect to both how, and how many, trees are logged; moreover, the choice of method often influences or determines the subsequent means of regeneration. Even-aged methods include *clearcutting*, in which virtually all the trees are removed from the site;[4] *stripcutting*, in which trees are removed in strips; *shelterwood* harvests, in which a sparse overstory is retained to shelter the regenerating stand, and is fully or partially removed in a subsequent harvest; and *seed-tree* harvests, in which a few trees are retained on the site to provide a natural seed source for the next stand. In uneven-aged systems, harvesting is a more continuous activity, and involves removal of a limited number of trees from a given area at a given time. Methods include *single-tree selection* and *group selection* (removal of groups of trees at one time). The method of harvesting — for example, cutting all the trees in a stand vs. removing a selected few — helps determine growing conditions for the regenerating seedlings, which in turn influence the species composition of the new stand. The method of harvesting may also determine whether artificial regeneration (planting) is feasible. Even-aged systems, especially with clearcutting, may use artificial regeneration to establish a new stand; uneven-aged systems typically rely on natural regeneration.

Whatever the method of harvesting used, trees must be transported from the stump to the *yard*, where logs are sorted and loaded onto trucks. Two ways of moving logs from the stump to the yard are possible: cable yarding systems, in which logs are attached to aerial cables and dragged or carried to a ridge top yard; and ground-based skidding systems, in which tracked or wheeled vehicles drag trees along "skid trails" to the yard. Although cable yarding systems are predominant in the steep forests of the West, the greater cost of cable systems makes ground skidding the method of choice throughout most of the relatively flatter South and North.

3. Site Preparation

This step is intended to produce conditions at a site that are amenable to rapid establishment of a new stand of desired trees. Objectives may include management of logging debris to facilitate planting of seedlings; elimination or suppression of unwanted species of trees or other plants that may interfere with establishment of the desired tree species; and, in the case of plantation establishment on wet sites, use of raised beds to alter soil moisture patterns. Methods to deal with debris may include burning (*slashburning*) or mechanical methods. Mechanical methods include *chopping*, *disking* and *shearing*, intended to reduce the volume of logging debris on the site or incorporate it into the soil; and *piling*, *raking* and *windrowing*, which remove debris from most of the site and place it in piles or "windrows." These methods are usually accomplished with bulldozers fitted with various types of blades, disks or drums. To remove unwanted or competing vegetation, fire or mechanical means may be used, as well as chemical treatment (use of herbicides) or even livestock grazing.

4. Regeneration

This step can occur by *natural regeneration*, through sprouting from stumps or roots (for hardwoods) or from seeds already in the soil, or through seed dispersal from trees in surrounding areas or those left in the harvested area. Alternatively, regeneration can occur through planting of seedlings, sometimes called *artificial regeneration*. As noted above, the method of harvest may help determine how new trees are regenerated. Uneven-aged silvicultural systems that use selection harvests generally employ natural regeneration, because forest cover remains on most of the site continuously. Even-aged silvicultural systems may use natural regeneration, either by leaving trees on the site as sources of seed (seed-tree harvests), by relying on already present seedlings in the understory (called *advanced regeneration*) or by timing clearcuts to coincide with seed production, thus facilitating germination and establishment of new seedlings after the harvest. Even-aged silvicultural systems also often employ artificial regeneration, which gives foresters more control over the pace and success rate of regeneration, the species composition of the next stand, the number of seedlings on the site and even the genetic makeup of the new stand — all factors that generally help to improve productivity of desired species.

5. Stand Tending and Protection

This step is temporally the longest, stretching from planting to harvest. It often includes *competition control* — measures employed to favor desired species and retard the growth of unwanted trees, shrubs and other plants that might compete for light, moisture or nutrients. Competing plants may be cut directly (*mechanical competition control*), killed or suppressed with chemical herbicides, or controlled by managed, low-intensity fires (*prescribed burning*). Stand tending and protection may also include measures to protect seedlings from damage from grazing or browsing animals. Once trees are established, stand tending often involves controlling the number and composition of trees in the stand, by cutting non-commercial species and excess individuals of the desired species to allow optimal growth in the remaining stand (sometimes called *pre-commercial thinning*). In some cases, *pruning* of lower branches is also conducted. Other major activities are protection of the stand from destructive fires (which may itself involve controlled burns) and from outbreaks of insects (often by thinning or treatment with insecticides).

6. Commercial Thinning

As trees in a stand mature, especially in stands of species suitable for pulpwood, one or more thinnings may be conducted to earn revenue on trees that would otherwise be lost to crowding and mortality, and to spur further growth in the remaining crop trees. Over the course of a rotation, the total biomass removed through commercial thinnings can be a substantial proportion of total site biomass.

Current Efforts to Mitigate Environmental Impacts of Forest Practices

Efforts to control or mitigate the potential environmental impacts of forest management include government regulation of forestry activities at federal, state and local levels, and voluntary efforts by private landowners or managers (for example, the forest products industry). This section briefly discusses current regulatory frameworks and the most prominent voluntary efforts underway, along with a consideration of other initiatives with potential to encourage environmental improvements in forest management.

1. Federal Requirements Affecting Forestry

Three federal statutes — the Endangered Species Act, the Clean Water Act and the Coastal Zone Management Act — contain provisions that may affect forest management by private landowners.

a. Endangered Species Act.
The Endangered Species Act (ESA) prohibits private landowners from “taking” an endangered species, defined as “killing, harassing, or harming.” By regulation, the U.S. Fish and Wildlife Service has defined “harm” broadly to include “significant habitat modification or degradation where it actually kills or injures wildlife by impairing essential behavioral patterns, including breeding, feeding or sheltering.” It is a violation of the ESA for a landowner who has endangered species on his/her property to harvest trees or conduct other forestry activities if the activity would harm an endangered species or degrade its habitat significantly.

b. Clean Water Act and Coastal Zone Management Act.
1. Forestry in Wetlands. The Clean Water Act (CWA) prohibits the discharge of any “pollutant” into U.S. waters (including wetlands) except in compliance with a permit or applicable regulatory standard. The term “pollutant” essentially refers to any human-caused alteration in water quality. Certain activities, including several associated with “normal silviculture,” such as plowing, harvesting, seeding and cultivating, are exempt from the permitting requirements of the CWA. To qualify as “normal,” the Environmental Protection Agency’s regulations require that the silviculture activity be “ongoing.” Activities that are intended to bring an area of the wetland into a use to which it was not previously subject, where the flow or circulation of waters may be impaired or the reach of the waters is reduced, are required to have a permit. The scope of the silviculture exemption has been the subject of a lawsuit.[5] In practice, to date government agencies have rarely required that private landowners obtain a permit before conducting forestry activities in wetlands.
2. Water Quality Protection. The CWA and the Coastal Zone Management Act (CZMA) require that states formulate programs to reduce water pollution from non-point sources, including forestry activities. The CWA requires that each state describe “Best Management Practices” (BMPs) which, when followed, will prevent or significantly reduce impacts on water quality from identified activities (see discussion of BMPs below). The CZMA requires that every coastal state formulate a program to reduce non-point source pollution in coastal waters specifically. Programs may include land use management

restrictions for areas where water-quality standards are not being met or may not be met in the foreseeable future and for state-identified "critical" coastal areas. The management measures may also include control measures for non-point source discharges similar to the BMPs referred to above.

2. State-level Regulation

Best Management Practices (BMPs), state-level legal requirements or guidelines to limit non-point source water pollution from forest management, exist in some form in all 38 major timber-producing states.[6] As discussed above, BMPs are required by federal regulations, although BMPs in some states pre-date federal involvement and a few states have enacted their own statutory requirements that go beyond federal requirements. The stringency and scope of BMPs vary widely: Some states have comprehensive forest practices acts, others have quasi-regulatory programs or mandatory BMPs, and just over half (20) have voluntary BMPs. State-level BMPs provide requirements or guidelines for forest management activities including road and skid trail construction, streamside management zones, harvesting and site preparation.

3. Voluntary Efforts

Voluntary efforts on the part of the forest products industry to mitigate the potentially adverse environmental impacts of forest management include collective initiatives by the industry as a whole and steps taken by individual companies.

a. AF&PA's Sustainable Forestry Initiative.
The most recent voluntary effort is the Sustainable Forestry Initiative (SFI), released in October 1994, by the American Forest & Paper Association (AF&PA).[7] The SFI, which sets out general goals and objectives for member companies,[8] is the most comprehensive expression of the forest products industry's collective effort to improve forest management on its lands. In several ways, the initiative's Principles and accompanying Guidelines represent important strides by the industry in addressing concerns about the environmental impacts of forest management. The Principles emphasize sustainable forestry, including the conservation of non-timber values such as soil, air and water quality, wildlife and fish habitat, and aesthetics. The Principles also acknowledge the importance of continuously improving management based on monitoring and reporting of performance.

Through objectives and performance measures for sustainable forestry, the Guidelines acknowledge the importance of many specific environmental issues, such as water-quality protection, riparian zones, wildlife habitat preservation (including "the conservation of plant and animal populations found in forest communities") and conservation of biological diversity. Moreover, the Guidelines commit member companies to encourage similarly sustainable practices on the part of others, such as loggers and other landowners from whom they purchase wood.

As expected for an initiative developed by the industry's trade association, the Guidelines do not contain specific performance standards in most areas, leaving the administration and execution of the stated objectives up to individual companies. While AF&PA will review company plans, the lack of measurable standards may make verification of compliance difficult or impractical; and the absence of specific performance standards for most of the objectives makes the effectiveness of an individual company's plans hard to measure.

b. Sustainable Forestry Efforts by the Society of American Foresters.
In 1993, the Society of American Foresters (SAF), the professional organization representing the forestry profession as a whole, released a report entitled "Sustaining Long-term Forest Health and Productivity," prepared by a task force with members drawn from industry, academia, the SAF, private consulting firms, a private foundation, the Forest Service, and state forestry departments.[9] The report emphasized the importance of adopting ecosystem management, which it defined as the "strategy by which, in aggregate, the full array of forest values and functions is maintained at the landscape level." Ecosystem management, as defined in the report, focuses on maintaining the integrity of natural systems intact; key elements include biological diversity, soil fertility and conservation of genetic diversity. Although the report sparked controversy upon its release, and continues to provoke debate, its issuance by the SAF represents recognition by much of the forestry profession of the need for new approaches to forest management.

c. Voluntary Efforts by Individual Companies and Landowners. In addition to the collective effort represented by the AF&PA Sustainable Forestry Principles, individual efforts have been taken by companies throughout the industry to mitigate or offset potential adverse environmental impacts from forest management. These measures include:

- Habitat Conservation Plans, which are agreements with the U.S. Fish and Wildlife Service to incorporate consideration of endangered species into forest management in return for being judged compliant with the federal Endangered Species Act.
- Programs to preserve "special areas," local sites on forest industry lands singled out for their biological, historical or geological significance.
- Land grants to conservation organizations, such as The Nature Conservancy.
- Efforts by some companies to manage for important landscape features, by protecting riparian zones, by creating wildlife corridors and by identifying and managing for landscape features such as subsurface water corridors.
- Initiating or participating in multi-landowner efforts to address landscape-level (for example, watershed) environmental issues that cross ownership boundaries.
- Landowner assistance programs.

Forest management can affect forest productivity, water quality, plant and animal diversity, and the preservation of important natural forest communities and ecosystems.

Independent efforts have also been undertaken by non-industrial private landowners: As an example, a Habitat Conservation Plan has been developed for non-industrial private landowners in the Sandhill region of North Carolina, in order to foster management that conserves habitat for the endangered red-cockaded woodpecker.

d. Logger Education, Training and Certification. In addition to the regulatory and voluntary efforts mentioned above, another ongoing effort to monitor and improve environmental performance in forest management is logger education, training and certification. Logger education and training programs (for example, Best Management Practices) are already underway in many states, and calls for more comprehensive programs have been put forward by many stakeholders, including the AF&PA. Formal logger certification programs, which would accredit loggers who had demonstrated knowledge of and compliance with Best Management Practices and sound management, are not specifically addressed in the AF&PA document but are supported by some individual paper companies.

e. Third-party Certification of Forest Management or Forest Products. Third-party certification is the process by which an independent third party (that is, neither purchaser nor supplier) with predetermined criteria for forest management assesses the performance of a given company, tract of land or operation (for example, harvest) and, if the criteria are met, offers its "certification" of sound forest management. Several third-party certification groups are already in operation and have certified a few tracts of land in the United States. To date, the focus of certification has been on lumber rather than on pulp and paper products.

A major issue surrounding third-party certification standards is how standards are set. If parameters and criteria differ among certifiers — as they do now — comparisons among companies certified by different entities can be difficult or impossible. A possible solution is to establish an oversight body to standardize the criteria used in certification; this is the goal of the Forest Stewardship Council (FSC), an independent, international body being set up with the intention of certifying the certifiers, based on the FSC's "Principles and Criteria for Natural Forest Management."[10] These principles and criteria embody a set of environmental objectives remarkably similar to those articulated in the AF&PA and SAF initiatives just subscribed: conservation of "biological diversity and its associated values, water resources, soils and unique and fragile ecosystems and landscapes." FSC places much greater emphasis, however, on maintenance of natural forests, restricting their replacement by tree plantations. (Unlike the AF&PA and SAF initiatives, the FSC's guidelines also encompass non-environmental goals related to indigenous peoples and forest industry workers' rights, local economic viability and community impacts.)

A second challenge facing certification, the so-called "chain of custody," is even more of a challenge for pulp and paper products than for solid wood products. Pulpwood may pass through several hands from the time it leaves the forest as harvested timber until it emerges from a paper machine as a ream of paper, and tracking it along the way to verify that a given ream of paper came from a certified timber harvest can be logistically difficult, especially for an outside party. The problem is compounded by the process of pulp and paper manufacturing: Pulpwood from many different sources may be mixed together in chip piles and in pulping operations, making determination of the exact origins of a particular ream of paper nearly impossible.

In principle, third-party certification provides an independent, objective, and standardized assessment of harvesting practices. If performed with technically sound and consistent standards, third-party certification could provide purchasers with reliable information about the relative environmental soundness of different companies' harvesting practices. However, some obstacles remain, and several important issues lie in the details of the standards and procedures used in certifying suppliers; these remain to be resolved. At the present time, it remains to be seen whether the FSC can attract sufficient support from the range of stakeholders to fulfill its mission.

II. RECOMMENDATIONS FOR PURCHASING PAPER PRODUCTS MADE FROM FIBER ACQUIRED THROUGH ENVIRONMENTALLY PREFERABLE FOREST MANAGEMENT PRACTICES

Introduction

1. Environmental and Economic Context for the Recommendations

The Paper Task Force has conducted extensive research into the environmental and economic implications of managing forestlands for the production of pulpwood, the virgin raw material used to make paper and paperboard products. This research documents a range of potential and actual environmental impacts associated with such management practices, including adverse effects on forest soils and productivity; water quality and aquatic habitat; plant and animal habitat and diversity; and the preservation of important natural forest communities and ecosystems.[11] Our research has also documented a broad range of measures that can be taken, and in many cases are being taken, to mitigate or avoid such impacts, including federal laws, state-level Best Management Practices[12] and other guidelines, and voluntary efforts such as the recently released AF&PA Sustainable Forestry Principles and Implementation Guidelines and the Forest Stewardship Council's Principles and Criteria for Natural Forest Management. (This research is summarized in the Task Force's findings on environmental issues associated with forest management, presented starting on page 149.)

Economic costs and benefits are associated with both the environmental impacts and mitigatory measures associated with forest management, although many such costs and benefits may accrue to different parties in both the public and private sectors, and their magnitude can be difficult to estimate.[13] For example, certain intensive management practices are used because they enhance the volume yield of timber products, providing economic benefit to the landowner. Adverse impacts that may arise from such practices can in turn impose costs on other landowners or on the public at large. Steps taken to address these impacts may well impose costs on the landowner if they reduce productivity, but may well provide economic benefits to other landowners or to the public at large. Not all cases involve such tradeoffs, however: Some forest management practices may reduce productivity over the long term (for example, through nutrient depletion), as well as cause adverse environmental impacts; steps to mitigate them can result in net economic benefits both to the landowner and to other parties. (These issues are explored in detail in the Task Force's research on economic considerations associated with forest management, the findings from which are presented starting on page 153.)

We have identified some intensive management practices that should be avoided under virtually all settings and conditions; however, most forest management practices can be carried out in an environmentally acceptable manner *if* applicable Best Management Practices and other appropriate safeguards are used, *and if* the practices are applied only in appropriate locations, avoiding environmentally sensitive and valuable lands such as rare or declining natural forest communities.

We also have identified several examples of less intensive management approaches that can provide both economic benefit to the landowner and enhancement of the environmental value of the land. These approaches are particularly applicable to non-industry private lands[14] — which constitute the majority of forestland in the United States and which are the source of over half of all pulpwood used by the forest products industry. Ensuring that sound forest management practices are applied on these lands — a task that can be greatly aided by members of the forest products industry in their role as the major purchasers of wood from such lands — constitutes the greatest opportunity and challenge facing those working to minimize the adverse impacts of forest management.

2. Objectives of the Task Force Recommendations

The Task Force has identified 10 basic recommendations for purchasers to follow that arise from its research on forest management practices. These recommendations are set out starting on page 133. The recommendations support the following three overarching objectives of sound forest management:

- Management of lands owned by forest products companies in a manner that preserves and enhances the full range of environmental values forestlands provide (Recommendations 1-7).
- Extension of environmentally sound management practices to non-industry lands from which forest products companies buy wood for their products (Recommendation 8).
- Promotion of sound forest management at a landscape level and across ownership boundaries, including increased support for natural and less intensive forms of management on public and non-industry private lands (Recommendations 9 and 10).

3. Context for Purchasers

Consideration of forest management issues in the context of paper purchasing and use is at an early stage. Much of the information presented and many of the recommendations offered will be new, and at least initially may seem complex, to many purchasers. Our objective here is to offer recommendations to purchasers that will begin a process of increasing demand for paper products made from fiber derived from sound forest management practices. Through these recommendations, we intend to:

- Enhance the awareness and knowledge of purchasers and users of paper, by providing clear information on the consequences of forest management practices used to produce paper products.
- Formulate a number of straightforward actions that purchasers can take, to demonstrate their desire for environmentally preferable forest management to their existing and prospective suppliers of paper products, thereby recognizing existing sound management practices and helping to spur needed changes.
- Provide specific performance measures purchasers can use in evaluating and comparing their suppliers' practices that will allow them to make environmental considerations associated with forest management an explicit purchasing criterion, to be considered alongside more traditional criteria such as cost and product performance.

4. Structure of the Recommendations

Under each recommendation presented below, we first provide one or more *supplier*[15] *implementation measures*, in order to help purchasers use the recommendations to assess or compare suppliers' practices and other activities. These measures identify more specific actions or commitments that purchasers can look for in prospective suppliers, or that they can request or require of existing suppliers, in order to achieve or advance each recommendation. All of the recommendations and their associated supplier implementation measures are summarized in Table 1.

Next, a brief rationale for each recommendation and supplier implementation measure is provided; supporting environmental and economic findings (presented in Section IV of this chapter) are indicated in Table 1. Following the rationale, we briefly discuss timing issues with regard to when a purchaser can apply the implementation measures to its suppliers, and generally how quickly compliance should be expected. We have characterized the measures either as *immediate*, meaning that a purchaser can readily and quickly request or require the measure of its suppliers, or as *continuous* or *incremental*, meaning that initial steps can be taken immediately to begin implementation of the measure, while full implementation will likely require time and purchaser vigilance to ensure that a supplier steadily progresses toward implementation of the measure.

Finally, we also discuss whether implementing the measure is likely to increase costs to the supplier; by necessity, this discussion is qualitative, but it indicates whether costs are likely to be incurred and the factors involved.

5. Purchaser Implementation Options

A variety of means exist by which a purchaser can act to influence and evaluate the forest management practices of its supplier(s). Which of these options are appropriate in a given situation will depend on factors such as the nature of the relationship between purchaser and supplier, the current status of a supplier's forest management practices, the ease with which or pace at which a supplier can be expected to implement a given measure, and the priorities and capabilities of the purchaser. We have identified, therefore, a menu of *purchaser implementation options*, several or all of which can be applied by a purchaser to advance a particular recommendation or supplier implementation measure; some of these options are designed to facilitate immediate implementation, while others are tailored to more continuous or progressive implementation. These options are presented in full in Section III below, starting on page 147. The purchaser implementation options can be categorized as follows:

- *Dialogue with suppliers:* Raise to your suppliers the issues of concern to you as a purchaser, and ask what they are doing to address them.
- *Reporting:* Request or require reports from your suppliers providing the information you need to evaluate their practices.
- *Goal-setting:* Set goals for specific objectives for your supplier(s) to meet.
- *Purchasing conditions:* Specify to your suppliers conditions they need to meet to keep your business.
- *Auditing/certification:* Use audits or certification of your suppliers as a basis for evaluating their performance.

We recognize that many purchasers buy paper through a variety of entities, often involving a paper broker or other intermediary (see endnote 15). The term *supplier* as used in these recommendations is tailored to a situation in which the supplier is a forest products company with whom the purchaser has a relatively direct purchasing relationship. Purchasers that buy paper from intermediary suppliers can nevertheless demonstrate their preferences directly to them and request that they in turn pass such information back up their supply chain. Intermediary suppliers can also be encouraged or requested to themselves adopt these recommendations and incorporate them into their business relationships with entities from whom *they* buy paper. Proactive purchasers may wish to link their volume of business with such suppliers to the extent to which they are able and willing to offer papers made using fiber produced in accordance with these recommendations. These suppliers may in turn be able to gain a business advantage by offering such papers to other customers as well.

Table 1

Application Of Purchaser Implementation Options
To Forest Management Recommendations

Recommendations	Supplier Implementation Measures	Supporting Findings from Section IVA (environmental Findings) and Section IVB (Economic Findings)	Purchaser Implementation Options				
			Dialogue with Suppliers	Periodic Reporting	Goal-Setting	Purchasing Conditions	Auditing/ Certification
			Query your supplier about its practices	Request/require periodic written reports	1. Ask supplier to set goal and report progress 2. Set goal and timetable yourself or jointly with supplier 3. Ratchet initial goal level up over time	1. Make compliance a condition of purchase 2. Request/require efforts beyond compliance	1. Request/require supplier audit/certification 2. Conduct your own audit/certification 3. Request/require independent audit/certification
A. Recommendations to advance environmentally sound management of suppliers' forestlands.							
1. Comply with AF&PA SFI, applicable laws and regulations	1. Develop and carry out SFI implementation plan	A3					
	2. Comply with applicable laws and regulations	A1					
2. Manage lands to maintain soil/water quality	1. Meet or exceed BMPs, other requirements	A1, B15					
	2. Use preferred/avoid damaging practices	A4-5, B15					
3. Adopt an "adaptive management" approach	1. Continuously monitor progress	A4					
	2. Conduct internal environmental assessments	A4					
	3. Use inventory and monitoring technologies	A4					
4. Seek outside assistance and perspective	1. Develop mechanisms to solicit input	B15					
5. Manage lands to maintain biodiversity	1. Conduct wildlife inventories/research	A4					
	2. Maintain habitat diversity	A4, B9-12, B15					
6. Manage lands to preserve natural communities	1. Identify natural communities	A5					
	2. Avoid management leading to decline	A5, B15					
	3. Concentrate intensive management on lands of lower ecological value	A8, B12					
7. Minimize impacts from harvesting	1. Manage clearcut size/placement	A6-7, B11-15					
	2. Ensure prompt regeneration	A6-7, B11-15					
	3. Avoid clearcutting under certain conditions	A6-7, B11-15					
	4. Minimize impacts of selective harvesting	A6-7, B11-15					
B. Recommendation to extend environmentally sound management to non-industry lands from which forest products companies buy wood for their products.							
8. Extend sound management to wood procured from other lands, including "gatewood"	1. Identify sources of pulpwood	B4-7, B11-13					
	2. Ensure management in accord with BMPs, AF&PA SFI and other sound practices	B4-7, B11-13					
	3. Purchase from certified loggers where possible	A3					
C. Recommendations to advance environmentally sound forest management on a landscape level, encompassing public and non-industry private lands.							
9. Aid in management at landscape level, across ownership boundaries	1. Work with others to ensure landscape integrity and habitat diversity	A3-4					
10. Promote sound management of public and non-industry private lands	1. Encourage reforestation, natural management on non-industry private lands	A4, A8, B6, B11-13					
	2. Lessen reliance on wood from ecologically sensitive or valuable public lands	A4-5, A8, B4-5					

Recommendations and Implementation Measures

The Paper Task Force believes that purchasers should urge their existing or prospective suppliers to be proactive in addressing the following recommendations, both in the management of their own lands and in their procurement of pulpwood from other lands. The recommendations are grouped under headings that reflect the three key objectives as set out above. The first seven recommendations address forest management practices as applied primarily to suppliers' own lands, while the latter three are aimed at extending management objectives to public and non-industry private lands as well. The Paper Task Force believes that the measures under the first four recommendations are ones that purchasers should expect to be carried out by all of their suppliers; compliance with them is straightforward and immediately feasible. The remaining recommendations contain measures that can be initiated immediately, although some will take time to fully implement. Purchasers should use suppliers' progress toward their implementation as a yardstick by which their environmental leadership can and should be judged.

Where more than one supplier implementation measure is provided under a given recommendation, their order reflects a logical sequence for implementation, and is not meant to imply relative environmental importance.

Recommendations to advance management of lands owned by forest products companies in a manner that preserves and enhances the full range of environmental values forestlands provide.

Recommendation 1. Purchasers should demonstrate a preference for paper made by suppliers who — at a minimum — operate in compliance with the principles and implementation guidelines for sustainable forestry as published by the American Forest & Paper Association (AF&PA), collectively known as the Sustainable Forestry Initiative (SFI), and should buy only from suppliers in compliance with all applicable environmental laws and regulations.

- *Supplier implementation measure: Develop and carry out a SFI implementation plan.* Suppliers should develop and carry out a specific policy and plan to implement the Sustainable Forestry Principles and Implementation Guidelines developed by AF&PA in all their operations, both domestic and abroad. The policies and plans should be made available to purchasers who request to review them.
- *Rationale.* The principles articulated in the SFI correspond closely to many of the key issues identified by the Paper Task Force as necessary to ensure that forest management practices are *sustainable*, that is, that they will ensure that forests in the future will provide the full range of benefits, environmental as well as economic, such lands are capable of providing. Specific measures to implement the principles are generally not contained in the SFI, as implementation is in most cases left up to the individual member.

  AF&PA members will be required to submit an annual report to AF&PA describing their compliance with the principles and guidelines. While AF&PA will issue an annual report summarizing the reports of its members, the individual reports are not required to be made public. In order to evaluate and compare the performance of individual suppliers in implementing the SFI, however, purchasers will need to have access to the reports that AF&PA members are required to submit. Purchasers should request to examine these reports, and suppliers should make them available.
- *Timing and cost considerations.* As of January 1, 1996, compliance with the SFI is a condition of continued membership in AF&PA. Given this condition, and the fact that most paper suppliers are AF&PA members, implementation of this measure should be straightforward, and can be undertaken immediately by such suppliers. These factors also mean that, while AF&PA has indicated that costs will be incurred by many of its members to comply with the SFI, no additional cost will be incurred to comply with this supplier implementation measure, at least for paper companies that are AF&PA members.

  The SFI principles and guidelines are equally actionable by non-members, as is preparation of a report detailing how the supplier complies with them. While applying this supplier implementation measure to non-AF&PA members will mean additional costs for them, such costs will serve to level the playing field across all suppliers.

- *Supplier implementation measure: Comply with applicable laws and regulations.* Suppliers should show that they meet or exceed all applicable laws and regulations pertaining to forest management, including those under the Clean Water Act, the Coastal Zone Management Act and the Endangered Species Act, as well as applicable international, state and local requirements.
  - *Rationale, timing and cost considerations.* Compliance with all applicable laws is a basic requirement of any business. This is a straightforward measure that suppliers can and should immediately apply. No additional costs should be incurred by complying with this measure.

Recommendation 2. Purchasers should demonstrate a preference for paper made by suppliers that manage their lands in a manner that protects on- and off-site water quality and conserves soil productivity. Such management includes operating in full compliance with all applicable mandatory or voluntary Best Management Practices (BMPs) and other applicable laws and regulations related to water quality, as well as any additional steps needed to meet the objective.

- *Supplier implementation measure: Meet or exceed BMPs and other related requirements.* Suppliers should show that they meet or exceed all applicable Best Management Practices as well as state and federal water-quality laws and regulations.
  - *Rationale.* A number of different forest management practices have the potential to adversely impact water quality. Because of this, Best Management Practices (BMPs) have been established to mitigate such effects. BMPs are mandatory in some jurisdictions, voluntary in others. When followed, BMPs are generally effective at mitigating water-quality impacts from forest management. BMPs vary from state to state, however, and in some cases enhancements to BMPs are needed (for example, extending some degree of riparian protection to intermittent as well as perennial streams).

    BMP compliance surveys in states where compliance is voluntary indicate inadequate compliance with certain BMPs. In some but not all such surveys, higher compliance levels have been found on industry lands relative to non-industry lands. Compliance levels are generally higher in programs that have been in place longer and have conducted active outreach, education and training.
  - *Timing and cost considerations.* This is a straightforward measure that suppliers can and should immediately apply as a basic requirement. Most forest products companies state that they already comply with applicable BMPs and other requirements in managing their lands, so few or no additional costs should be incurred by complying with this measure.
- *Supplier implementation measure: Avoid practices that can damage water quality or site productivity.* Suppliers should implement forest management practices in addition to BMPs as needed to protect water quality and maintain site productivity. Several such broadly applicable practices are:
  - –The avoidance of highly intensive harvesting methods — in particular, whole-tree harvesting on short rotations — *unless* top limbs and other residuals are returned to the site or site-specific data conclusively demonstrate sufficient naturally occurring reserves and/or inputs of *all* nutrients to offset losses in harvesting.
  - –The avoidance of routine use of site preparation methods involving windrowing or piling that remove slash and logging debris from all or part of the harvest site and can cause excessive soil disturbance or compaction.
  - –The use of surface water protection measures for all perennial and intermittent[16] streams and other bodies of water. Such measures should include the retention of buffer strips of trees along bodies of water, and limitations on the extent of harvesting and site preparation activities and on the use of heavy machinery within such buffers. While intermittent streams may require a lesser *degree* of protection, these measures are needed along all streams to ensure protection of water quality.
  - –In coastal areas, careful management of freshwater flows from cleared or otherwise altered forestlands.
  - *Rationale.* As with water quality, several forest management practices can adversely affect soil productivity, through nutrient depletion or physical changes (for example, soil compaction). Under some site conditions, uncertainty remains as to the ability of short-rotation forest management to maintain nutrient reserves and soil productivity

over the long term, especially without fertilization. Avoidance of highly intensive harvesting (whole-tree harvesting) and site preparation (windrowing, piling) techniques and other measures can generally mitigate such impacts, at least in the short term, and can be cost-effective by enhancing productivity. These methods may play a useful and acceptable role in selective situations; for example, the use of whole-tree harvesting for the *initial* harvest of a low-quality stand containing many unmerchantable trees may be warranted to avoid accumulation of excessive debris. Repeated use of such methods, however, can lead to adverse impacts and should be avoided.

Retention of buffer strips of trees along streams and other bodies of water has been shown to be highly effective at mitigating many of the potential water-quality impacts of forest management. For example, buffer strips act to filter out sediment or other pollutants that can degrade water quality or aquatic habitat, and also provide shade that moderates water temperature fluctuations. Because during storm events or wetter parts of the year, water entering intermittent streams typically flows into a perennial body of water, buffer strips along these streams are needed as well to avoid degradation of water quality. Lesser restrictions on the extent of harvesting in buffer strips along intermittent streams may often be warranted, however, as there is less need to retain sufficient shade to avoid adverse water temperature fluctuations in such streams.

In coastal areas, fresh water draining from cleared forestlands can act as a pollutant by decreasing the salinity of sensitive estuarine areas. This off-site water-quality impact is of particular concern when coastal wetlands are converted to plantation management, because of their proximity and connectivity to estuarine areas: The increased water flow that typically occurs after such areas are clearcut (the predominant harvesting method used in such areas), often coupled with measures to rapidly remove such water from the site via drainage systems, can greatly increase the flux of fresh water from such areas.

- *Timing and cost considerations.* Purchasers should expect their suppliers to begin implementing such measures immediately.

Intensive management practices such as those discussed above that affect nutrient reserves or soil quality can lead to reductions in productivity that would increase pulpwood production costs for suppliers. Hence implementing this measure can avoid such costs. Riparian protection measures will generally reduce the yield from areas that include bodies of water, raising overall wood procurement costs for the supplier. However, numerous studies have found these measures to be among the most cost-effective of all water-quality protection measures. Moreover, most state BMPs require some such measures already, although they are not always applied to intermittent streams.

Recommendation 3. Purchasers should demonstrate a preference for paper made by suppliers who develop and implement an adaptive management approach, through actively engaging in and keeping abreast of research on the environmental impacts of forest management practices, coupled with a commitment to modify their practices as needed in response to research results.

- *Supplier implementation measure : Continuously monitor and improve environmental performance.* Suppliers should commit to “adaptive management”: continuous monitoring of environmental performance and prompt application of research findings to improve management techniques.
- *Supplier implementation measure: Conduct internal environmental assessments.* Suppliers should develop internal environmental assessment programs and incorporate the results into a report made available for the purchaser’s review.
- *Supplier implementation measure: Use environmental inventory and monitoring technologies.* Suppliers should use technologies such as Geographic Information Systems (GIS) to record and assess environmental information such as surveys of wildlife habitat and to identify possible management methods to improve habitat or other ecological values on the lands they manage.

The ability to adapt forest management practices to reflect new environmental information, coupled with active and ongoing monitoring of environmental performance, is essential to success.

[NOTE: The following rationale and feasibility sections apply to all three implementation measures above.]

- *Rationale.* Many aspects of our understanding of the environmental consequences of forest management could be further improved by additional research. While there is fairly broad consensus on many of the environmental goals associated with improved forest management, there is much less agreement — and objective data — on what is needed to get from here to there. Research is therefore critical to improving existing practices. As has been found in many aspects of forest management associated with productivity, the ability to adapt management practices to reflect new data obtained through active environmental research, coupled with active and ongoing monitoring of environmental performance, is essential to success.
- *Timing and cost considerations.* Purchasers can and should expect their suppliers to begin implementing such measures immediately, although research will obviously require time and although modifications to management practices will need to proceed more incrementally. Purchasers also can immediately begin evaluating and comparing their suppliers on the basis of their commitment to adaptive management.

Conducting research and assessments and implementing new monitoring technologies entail up-front costs. However, most companies already have at least some of the management infrastructure; existing productivity-oriented research and monitoring capabilities can be expanded to include additional environmental objectives, so that incremental costs are likely to be relatively small. It is less clear whether subsequent changes in management practices need always increase a supplier's costs; indeed, such investments in research and monitoring could well help to identify more cost-effective means of adapting management to enhance environmental values.

Recommendation 4. Purchasers should demonstrate a preference for paper made by suppliers who actively seek outside assistance, advice and perspective from the full range of other stakeholders and interested parties in issues surrounding forest management.

- *Supplier implementation measure: Develop mechanisms to solicit imput.* Suppliers should develop or participate in efforts to solicit input on forest management from other stakeholders, using mechanisms such as forestry extension services and forums that facilitate dialogue with interested and affected parties.
- *Rationale.* The existence of broader social costs and benefits associated with forest management, and the fact that its environmental consequences (and costs associated with mitigating such impacts) extend beyond ownership boundaries, argue that forest management decisions will be far more sound, credible and socially acceptable if made with a full understanding and consideration of the range of expertise and perspective of parties beyond the landowner.
- *Timing and cost considerations.* Purchasers can immediately begin evaluating and comparing their suppliers on the basis of the leadership, commitment and cooperation suppliers demonstrate in seeking outside views on the management questions they face.

Whether significant costs will be incurred by implementing this measure will depend primarily on what changes in management methods are made by the supplier. Whether these management changes lead to increased costs will be determined by the factors already discussed above in Recommendation 3.

Recommendation 5. Purchasers should demonstrate a preference for paper made by suppliers who manage their lands in a manner that contributes to the conservation of biodiversity[17] *by maintaining or enhancing habitat for a broad array of plants and animals, with an emphasis on rare and endangered species.*

- *Supplier implementation measure: Conduct wildlife inventories and research on landscape management.* Suppliers should develop wildlife and wildlife habitat inventories of their lands, and conduct and support research on landscape management, ecosystem functions and the conservation of biological diversity. In keeping with an adaptive management approach, the knowledge gained through such research should be applied expeditiously to modify forest management as needed to enhance the diversity and quality of wildlife habitat and to preserve biodiversity on supplier-owned lands.
- *Rationale.* Managing for wildlife habitat and diversity requires a good understanding of wildlife and types of habitat that already exist, to use as a baseline. Additional

research is important to further our understanding of how forestlands can best be managed to preserve and enhance habitat while yielding wood products. Equally important is having in place mechanisms that allow research results to modify present practices as needed to enhance biodiversity.

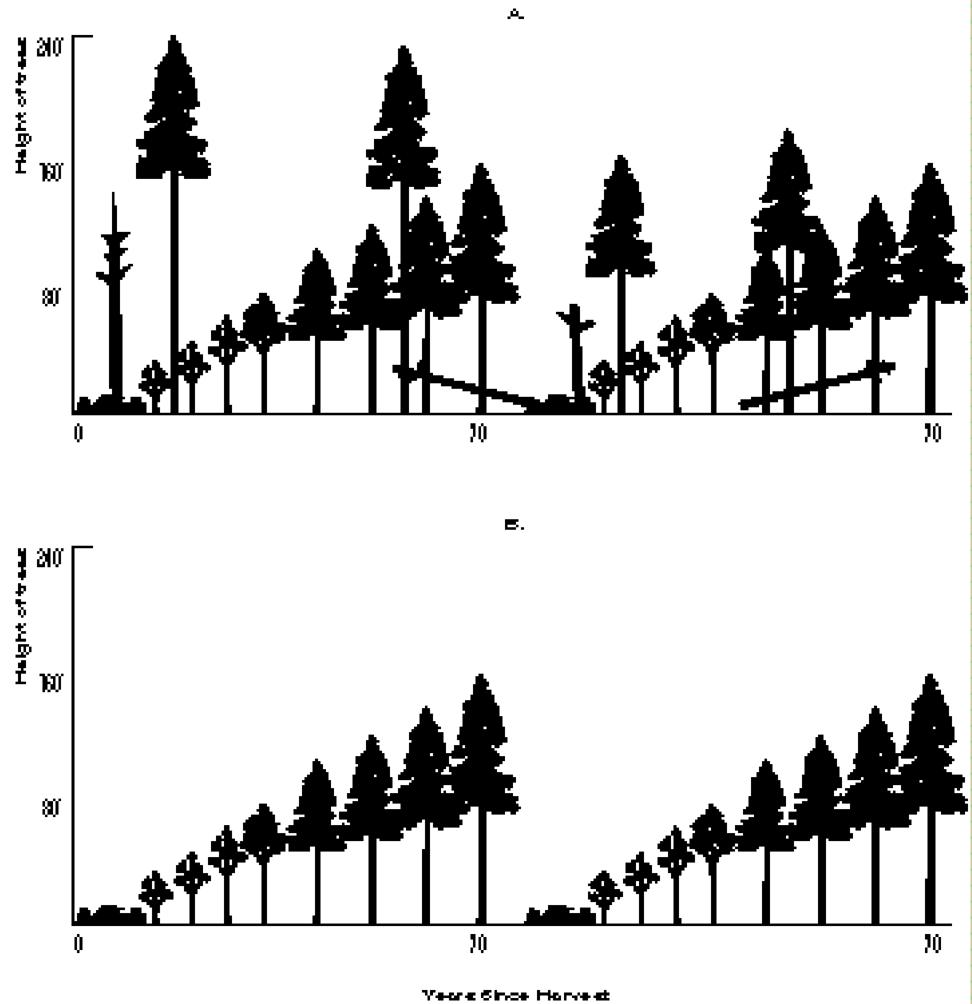
- *Timing and cost considerations.* Purchasers can and should expect their suppliers to begin implementing such measures immediately, although research will obviously require time and although modifications to management practices will need to proceed more incrementally.

  Conducting or supporting research and developing wildlife inventories entail up-front costs, although most companies already employ wildlife biologists and hence their incremental costs are likely to be relatively small. It is less clear whether subsequent changes in management practices need always increase a supplier's costs; indeed, such investments in research and monitoring could well help to identify more cost-effective means of adapting management to enhance environmental values.

- *Supplier implementation measure: Employ measures to maintain and enhance habitat diversity.* Suppliers should employ measures to maintain and enhance wildlife habitat diversity on their lands, especially habitat for rare and endangered species. Because stands of trees managed for lumber or fiber production typically tend to favor wildlife adapted to disturbance and to provide habitat corresponding to only a limited range of forest stages, suppliers should implement management measures to ensure that as broad an array as possible of habitat is provided on their lands even where the primary management objective is wood production. The nature and extent of habitat-enhancing measures needed on a supplier's land will depend on factors such as the overall management intensity currently employed by the supplier; the specific arrangement and size of intensively managed stands within the larger land holding; the location of the land the supplier owns in relation to other nearby forested lands; and the extent to which such surrounding lands provide habitat values that may benefit from, or suffice in the absence of, the provision of additional habitat on the supplier's land. Appropriate measures to promote habitat diversity may include:

Figure 2

Stand Structure Under Two Management Scenarios



These figures illustrate the structure of an idealized forest stand managed (A) with retention of old trees, snags, and downed logs, and (B) with removal of all trees and logging debris at harvest, as is done under conventional management. Although the stand represented here is a hypothetical Douglas-fir stand in the Pacific Northwest, it is useful as a general depiction of the simplification of stand structure under conventional management.

Source: See Endnote 19.

–The use of wildlife corridors[18] and other types of set-asides that provide or maintain habitat.

–The maintenance of a diverse tree species mix (for example, hardwood or mature longleaf pine stands or inclusions within a loblolly pine plantation).

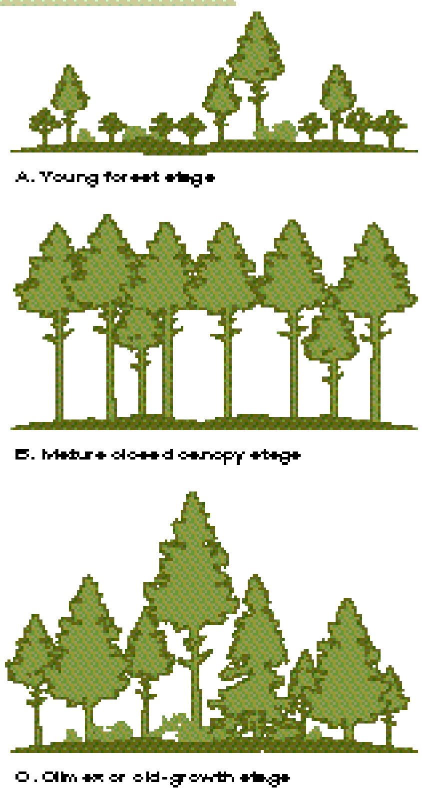
–The maintenance of some interior mature forest and other habitats different than the prevailing even-aged forest.

–The retention of several wildlife trees and snags per acre where they are important structural elements of natural forests in a given region. See Figure 2.[19]

–Other measures that can maintain or enhance structural diversity within and among stands.

Figure 3

Stand Structure in Three Stages of Forest Development After Disturbance



These drawings illustrate three stages in forest development, corresponding to *stand initiation* (A), *stem exclusion or closed canopy* (B) and *old-growth* (C). Note that the stand structures depicted here occur naturally; the proportion of forest in each stage, however, may be altered by management.

Source: See Endnote 20.

• *Rationale.* Forests managed primarily for wood production tend to exhibit less biodiversity than natural forests managed primarily for non-timber values. Production-oriented management practices, especially those used in even-aged and intensively managed systems, tend to narrow the range of successional stages present relative to those found in natural or less intensively managed forests, both by accelerating stand establishment (thereby hastening or eliminating early successional stages) and by harvesting before maturity is reached (thereby truncating later stages of stand development). See Figure 3.[20]

Even where the number of species may be comparable or even higher in a managed forest, the presence and abundance of rarer species tends to be lower than in a natural forest. Because production-oriented management tends to increase the proportion f a landscape in disturbed and early-successional stages, it tends to favor early-successional plant and animal species and those adapted to disturbance. Precisely because such habitat is relatively common (due not only to production-oriented forest management but also to land clearing for other purposes), the species it tends to favor are also relatively common. In contrast, species adapted to natural and undisturbed forest conditions tend to be rarer — and therefore of higher conservation priority — because such habitats are themselves rarer.

A number of modifications (indicated in the measure above) to traditional production-oriented management can enhance habitat potential within and surrounding the actively managed areas.

• Timing and cost considerations. Purchasers should expect their suppliers to begin implementing such measures immediately, but given the lengths of typical rotations and the diversity of conditions that can be expected on different lands, full implementation will need to proceed more incrementally.

To the extent measures of the types identified above require a lessening or avoidance of production-oriented management in certain areas, costs will be incurred in the form of lower volumes of wood products. (In contrast, on many non-industry private lands, less intensive management may actually be financially preferable for the landowner; see Recommendation 10 below.) In many cases, flexible management plans that incorporate such measures can help to minimize their costs. For example, wildlife corridors might be managed less intensively and on a longer rotation, but their location could be shifted over time to still allow them to contribute to production.

However, some of the measures listed above may have lower or no costs, and may even boost revenues. Managing for a more diverse tree species mix can also diversify the supplier's product base and might be directed to increase the abundance of more valuable species. Given the rising price paid for hardwood, pulpwood and sawtimber, allowing rather than suppressing its growth in otherwise pine-dominated stands may provide additional source of revenue, while avoiding the costs of competition control. Use of longer rotations to produce more mature forest conditions may also enhance the value of the final harvest, by allowing more wood to be sold as lumber rather than pulpwood. While pulpwood procurement costs would likely rise, these would be offset by revenues from the other products.

Recommendation 6. Purchasers should demonstrate a preference for paper made by suppliers who manage their lands in a manner that preserves ecologically important, rare or declining natural communities. Intensive management on lands representing such community types should be avoided; where necessary for preservation, management for wood production should not take place. Intensive management should be concentrated on lands of lower ecological value.

- *Supplier implementation measure: Identify important natural communities and ecosystems.* Suppliers should identify the location and extent of rare or declining natural communities and ecosystems on their lands. Such systems include certain types of wetlands (for example, some types of pocosins[21] and bottomland hardwood systems); longleaf pine forests; and old-growth forests.
  - *Rationale.* As with wildlife and habitat above, the first step in ensuring protection of natural communities is to have a full characterization of their occurrence on one's lands. The conservation priority assigned to various types of natural communities or ecosystems is a function of many factors, including: their rarity on a regional, national and global scale; the extent to which remaining occurrences are situated in contiguous blocks or are isolated or otherwise fragmented; their habitat value for plants and animals, especially for threatened or endangered species; their ecological functions (e.g., for wetlands, water filtration and flow modulation); their sensitivity to disturbance related to typical forest management activities; and the degree to which activities in addition to forest management for wood production (e.g., agriculture, development) may contribute to their further decline. State Natural Heritage Programs maintain listings of ecologically important natural community types within their borders, along with a relative ranking of their conservation priority. By way of illustration, one such listing for the State of North Carolina is provided in Table 2.[22] In working with suppliers to implement this measure, purchasers will likely need to consult with similar listings as well as experts familiar with the specific areas in question.
  - *Timing and cost considerations.* Purchasers can and should expect their suppliers to begin implementing such measures immediately.
- *Supplier implementation measure: Avoid management that impairs ecosystem function.* Suppliers should agree not to convert or significantly modify the ecological functions of any rare or declining natural ecosystems that occur on their lands. Plantation establishment and intensive management should

Table 2

North Carolina Natural Heritage Program List of Rare Natural Communities Occurring in North Carolina which Might Be Harmed by the Conversion of Wetlands to Pine Tree Farms, and Their Ranks Based on Rarity and Threat Status in the State

COMMUNITY TYPE	NORTH CAROLINA RANK*
Bay Forest	Rare or Uncommon
Coastal Plain Bottomland Hardwoods (Blackwater Subtype)	Rare or Uncommon
Coastal Plain Bottomland Hardwoods (Brownwater Subtype)	Apparently Secure
Coastal Plain Levee Forest (Blackwater Subtype)	Rare or Uncommon
Coastal Plain Levee Forest (Brownwater Subtype)	Apparently secure
Coastal Plain Small Stream Swamp (Brownwater Subtype)	Imperiled or Rare or Uncommon (precise rank uncertain)
Cypress Savanna	Critically Imperiled
High Pocosin	Apparently Secure
Low Pocosin	Rare or Uncommon
Nonriverine Swamp Forest	Imperiled or Rare or Uncommon (precise rank uncertain)
Nonriverine Wet Hardwood Forest	Critically Imperilled
Peatland Atlantic White Cedar Forest	Imperiled
Pine Savanna	Imperiled
Pond Pine Woodland	Apparently Secure
Sandhill Seep	Imperiled
Small Depression Pocosin	Critically Imperiled?
Streamhead Atlantic White Cedar Forest	Imperiled
Wet Marl Forest	Critically Imperiled
Wet Pine Flatwoods	Rare or Uncommon

*North Carolina ranks are based on The Nature Conservancy's system of measuring rarity and threat status. This system is now widely used by other agencies and organizations, as the best available scientific and objective assessment of a species' rarity at the state level. The "critically imperiled" rank may be assigned because of extreme rarity or because of some factor(s) making the community type especially vulnerable to extirpation (local extinction) from the state; the "imperiled' ranking may be assigned because of rarity or because of some factor(s) making it very vulnerable to extirpation from the state.

Source: See Endnote 22.

be avoided in these environmentally sensitive areas.

- *Rationale.* A number of rare or declining natural communities (delineated above) are at risk from forest management for wood production; in general, the risk increases with the intensity of management in such areas. Because of their rarity, extent of fragmentation and ecological value (for example, as reservoirs of biodiversity, endangered species habitat or wildlife habitat more generally), such communities are of high conservation priority. For some such communities, forest management historically has not been the major contributor to their decline, and presently may be only one of several contributors to their continuing decline or risk of decline.
- *Timing and cost considerations.* Purchasers can immediately make clear their concern for the preservation of natural communities present on the lands of their suppliers. Given the economic implications to the landowner of this measure, purchasers should expect incremental but continuous progress over time.

For most forest products companies, avoiding or lessening the intensity of management in these areas clearly entails economic costs to the landowner, likely increasing wood supply costs. Specific information on the magnitude of such costs is difficult or impossible to develop, given their high variability and site-specific and proprietary nature. (In contrast, on many non-industry private lands, less intensive management may actually be financially preferable for the landowner; see Recommendation 10, below.)

- ***Supplier implementation measure:** Concentrate intensive management on lands of lower ecological value.* Suppliers should take steps to concentrate intensive management on lands with lower ecological value. Such steps could include:
  - –Acquiring and engaging in intensive management on already cleared and disturbed lands of relatively lower ecological value, such as abandoned agricultural lands.
  - –Promoting and developing programs to encourage others to do the same.
  - –Setting aside environmentally sensitive areas, or selling or donating them (for example, as conservation easements) to recipients able and committed to maintain such areas in their natural state.
- *Rationale and cost considerations.* While any reduction in productivity from lands not managed intensively will clearly represent a cost to the landowner, there may be options for lessening or partially offsetting these costs:
  - –Intensifying the management of forestlands that are of lower ecological value can help to offset the reduced wood supply coming from sensitive areas.
  - –Reforestation of lands not currently forested through planting or facilitating natural regeneration can also help to offset the reduced wood supply coming from sensitive areas.
  - –Environmentally valuable or sensitive lands that are sold or donated to others able and willing to preserve them have associated revenue and public relations/good citizenship benefits.
- *Timing.* Purchasers can immediately begin evaluating and comparing their suppliers on the basis of the commitment suppliers demonstrate to make continuous progress over time in taking steps such as the ones outlined above.

Recommendation 7. Purchasers should demonstrate a preference for paper made by suppliers who employ harvesting methods that minimize the ecological impacts of harvesting, both at the level of individual stands of trees and across the landscape.

- ***Supplier implementation measure:** Carefully manage size and placement of clearcuts.* Suppliers should manage the size and placement of clearcuts to:
  - –Maintain sufficient habitat diversity and minimize fragmentation of wildlife habitat.
  - –Maintain sufficient structural diversity across the landscape.
  - –Conserve biodiversity at a landscape level.
  - –Reflect the predominant natural disturbance regime(s) for the specific region and forest type involved.
- ***Supplier implementation measure:** Ensure prompt regeneration.* Suppliers should select and employ harvesting methods only in the context of a strategy that ensures prompt, successful regeneration of the harvested site. Where artificial regeneration (that is, planting of seedlings) is employed, planting should occur within at most two years of harvest. For both artificial and natural regeneration, ongoing monitoring and assessment methods

should be employed to ensure within five years of harvest that regeneration has been successful.

- *Supplier implementation measure: Avoid clearcutting under certain conditions.* Clearcutting [23] should be avoided altogether in some areas, including those:
  - –Where severe soil erosion is likely, such as steep slopes.
  - –Where regeneration of a new stand may be impaired as a result of exposure to extreme climate or changes in populations of soil microorganisms.
  - –Along streams and other bodies of water.
  - –On lands harboring important plant and animal populations, such as endangered species habitat and rare natural communities.
- *Supplier implementation measure: Minimize impacts of selection methods of harvesting.* Where selection methods of harvesting [24] are used, they should be carried out in a manner that:
  - –Minimizes the frequency and extent of disturbance of soils and damage to surrounding trees arising from stand entries.
  - –Is coupled with the use of road construction and maintenance practices that minimize adverse impacts; these can arise from increased road use due to more frequent stand entries that can occur with selective harvesting methods.
  - –Retains or enhances after each harvest a full representation of tree species and a mix and age and size classes, thereby maintaining overall stand composition and quality and avoiding "high-grading," a practice in which only the best-quality trees in a stand are harvested, leaving behind a low-quality stand.

[NOTE: The following rationale and feasibility sections apply to all four implementation measures above.]

- *Rationale.* Both clearcutting (as part of an even-aged management system) and selective harvesting methods (as part of an uneven-aged management system) can have adverse environmental impacts. By removing all or most trees in a stand, clearcutting can increase windspeeds and soil temperatures and alter soil moisture levels. The consequences of these physical changes depend heavily on the forest type and on site conditions, but potentially include significant impacts on virtually all environmental values forests provide: forest soils and productivity; water quality; plant and animal habitat and diversity; and the physical extent and health of natural forest communities.

  While selection methods maintain greater wildlife habitat and structural diversity in the forest, they potentially can lead to "high-grading," especially where the best-quality trees in a stand are removed in each of several successive harvests. Selective harvesting methods can entail relatively frequent entries into a stand to carry out harvesting activities, and hence, may also require greater use and maintenance of road networks, which have been identified in numerous studies as a major source of erosion (with subsequent adverse water quality impacts). Such entries, especially those involving the use of heavy machinery, can also cause direct damage to remaining trees and compaction and disturbance of the soil, leading to reduced soil productivity and increased soil erosion.[25]

  Mitigating the effects of clearcutting requires avoiding the practice altogether in some areas where adverse impacts are particularly severe, and carefully managing the size and placement of clearcuts wherever the method is used, so as to ensure maintenance of habitat diversity at a landscape level. Finally, because regeneration failures have been associated with clearcutting, it is essential that steps be taken to ensure prompt regeneration, whether through planting or by natural regeneration. Avoiding the impacts of selective harvesting methods requires very careful, closely supervised application of such methods.
- *Timing and cost considerations.* Purchasers should expect their suppliers to begin implementing such measures immediately.

  Cost implications of the measures described above will likely vary considerably. Steps taken to ensure successful regeneration and improve overall stand quality will have positive economic impact on suppliers, especially when (appropriately) viewed over the long term. To the extent that other measures lessen or avoid production-oriented management in certain areas, the reduced volume of wood products will result in higher wood procurement costs for the forest products company. (In contrast, on many non-industry private lands, less intensive management may actually be financially preferable for the landowner; see Recommendation 10, below.)

Recommendation to extend environmentally sound management practices to non-industry lands from which forest products companies buy wood for their products.

Recommendation 8. Purchasers should demonstrate a preference for paper made by suppliers who use available means to ensure that environmentally sound practices are applied to the management of all lands from which the supplier buys wood. These requirements should extend to wood bought on the open market, commonly known as "gatewood."

- *Supplier implementation measure: Identify sources of pulpwood.* Suppliers should identify the sources of (and their proportional contribution to) the pulpwood used in their products. Sources may include company-owned lands; lands owned by other forest products companies; lands owned by non-industrial private companies, institutions or individuals; and national or state forests or other public lands.
  - *Rationale.* A substantial majority (on average across the industry, about 75%) of pulpwood originates from harvests on lands not owned by pulp and paper products companies. The great majority of this pulpwood comes from non-industrial private forestlands (NIPF), with the majority of it purchased on the open market, often as "gatewood," from loggers and other intermediaries between the landowner and the forest products company.
  - *Timing and cost considerations.* Purchasers should immediately articulate their desire to buy from suppliers who can identify the source of wood in their products, and expect a commitment from their suppliers to make continuous progress over time in achieving full sourcing information. Purchasers should expect that their suppliers are able to readily identify the source of pulpwood they receive from public lands, and from private landowners with whom they have contractual relationships or who are members of the supplier's landowner assistance program. Tracking the origin of wood bought from intermediaries such as loggers, while more difficult, can be achieved by the supplier imposing a requirement on these intermediaries that they identify the source of the wood they are selling. Obviously, the fewer links in the chain between original landowner and mill, the easier this will be to accomplish.

    Most suppliers will likely incur initial costs in setting up mechanisms to allow full tracking of pulpwood sources, especially for gatewood, where tracking is not currently done. The costs of complying with this measure can be moderated by extending mechanisms already in place for contracted supplies to additional sources.
- *Supplier implementation measure: Ensure management in accord with BMPs, the SFI and other sound practices.* Suppliers should take steps to ensure that *all* pulpwood they purchase for use in pulp and paper production is purchased from private landowners, loggers or other entities that fully comply with:
  - –All applicable Best Management Practices and the additional practices, specified in the second supplier implementation measure under Recommendation 2 above, needed to preserve soil productivity and water quality.
  - –All applicable provisions of the AF&PA Sustainable Forestry Initiative and other environmental performance standards set by the supplier itself for its own lands.
  - –The supplier implementation measures addressing harvesting practices specified under Recommendation 7 above.

  Suppliers should also actively encourage management practices on lands from which they purchase pulpwood that contribute to the conservation of biodiversity and the preservation of ecologically important, rare or declining natural communities; examples of such practices are provided under Recommendations 5 and 6 above.
  - *Rationale.* Because the great majority of pulpwood entering a given pulp mill is derived from lands other than those owned by the mill owner, affecting significant change in forest management associated with pulp and paper products requires extending beneficial practices "upstream" to the suppliers of the suppliers, especially to non-industrial private forestlands.

    Forest products companies already employ a number of mechanisms, in addition to their purchase of pulpwood, through which they interact with loggers or landowners from whom they procure wood. These mechanisms include contracts, landowner assistance programs, logger training and education.
  - *Timing and cost considerations.* In addition to knowing the source of the pulpwood, this measure requires the supplier

to exert some degree of control over practices used to produce the pulpwood. The most straightforward approach is for the supplier to articulate the above objectives in *its* purchasing preferences or requirements, and ultimately to buy pulpwood only from sources that can demonstrate they have met the objectives. Paper purchasers should immediately communicate their desire to buy from suppliers that can provide such assurances about the wood used in their products, and expect a commitment from their suppliers to make continuous progress over time toward a goal of full source control.

Cost implications of this measure are difficult to predict, as they depend ultimately on changes in the cost of wood purchased by the supplier due to imposition of the new conditions that must be met. The latter is in turn a function of the extent to which loggers and non-industry landowners are already complying with such conditions, the influence a mill exerts on pulpwood prices in its vicinity, and overall regional pulpwood market dynamics. Many landowners will be willing to abide by BMPs and other standards, given their strong land stewardship ethic or their management objectives. In times of short pulpwood supply, where loggers or landowners may be pressed or have incentives not to abide by such measures, forest products companies may face higher procurement costs in implementing this measure. An incremental approach to implementation of this measure should help to moderate costs.

- ***Supplier implementation measure****: Purchase from certified loggers wherever possible.* Suppliers should use and purchase pulpwood only from certified loggers where certification programs that address environmental aspects of forest management are in place. At the current time, such programs are not widespread, however. Suppliers should also participate in and promote logger training programs and landowner assistance programs that:
  – Provide an understanding of the rationale for and importance of compliance with Best Management Practices, the AF&PA Sustainable Forestry Initiative and requirements of other state and federal environmental laws.
  – Provide the most current information on the environmental effects of various forest management practices.
- *Rationale.* Loggers play a critical role with respect to the environmental impacts associated with the acquisition of pulpwood: They not only carry out the harvesting operation, but often serve as a primary source of information for the non-industrial private landowner; they also frequently barter the sale of wood they have harvested or intend to harvest. Ensuring that loggers and landowners are educated about the environmental impacts of forest management is vital to affecting changes in such practices. Where training and certification programs for loggers already exist, purchasing from only such loggers not only will increase the likelihood that the purchased wood is environmentally preferable, but also will provide an economic reward to the logger who undergoes training and certification, and an incentive for others to do the same.

Because most pulpwood comes from non-industry lands, it is essential that beneficial forestry practices be extended "upstream" to these lands.

- *Timing and cost considerations.* Purchasers should expect their suppliers to begin employing certified loggers immediately where suitable certification programs exist, and to expand their use of certified loggers as the programs expand. Suppliers' efforts to promote and develop logger and landowner education programs should begin immediately.

Where all loggers in an area are required to be certified, no additional cost should arise from employing them. Where certified and non-certified loggers both operate, whether costs accrue to the supplier will depend on the extent to which loggers incur additional costs to employ practices required by their certification as well as the factors previously mentioned: the influence of a mill on pulpwood prices in its vicinity and overall regional pulpwood market dynamics. An incremental approach to implementing the aspect of this measure involving use of certified loggers should help to moderate costs.

Training programs for loggers and landowner assistance programs already exist; introducing environmental considerations into such forums should entail relatively small incremental costs.

Recommendations to promote environmentally sound forest management at a landscape level and across ownership boundaries, including increased support for natural and less intensive management on public and non-industry private lands.

Recommendation 9. Purchasers should demonstrate a preference for paper made by suppliers who encourage and participate in the development of environmentally responsible management on a landscape level, including the implementation of management approaches that are applied across ownership boundaries.

- *Supplier implementation measure: Work with others to ensure landscape integrity and habitat diversity.* Suppliers should initiate or participate in initiatives with other landowners (public and private) and other interested parties to manage landscapes (for example, watersheds) in a manner that preserves and enhances the environmental integrity and value of such landscapes.
  - *Rationale.* Many of the most serious impacts of forest management are cumulative, that is, result from the application of a practice on many stands across a landscape. This is true even when their application at the stand level may be of minor consequence when viewed in isolation. In addition, various natural processes link together individual parcels of forestland, without regard to ownership boundaries. For example, forest management activities essentially anywhere within a watershed have the potential to affect the quality of water within and draining from the area. (For this reason, the State of Washington's Forest Practices Act requires landowners to conduct watershed-level assessments and planning.)

    Maintaining or restoring ecological functions served by forestlands requires allowing for activities or processes that often extend beyond ownership boundaries. For example, using wildlife corridors to link separated areas of relatively undisturbed habitat for certain animal species will work only if the corridors extend through all of the intervening more heavily managed lands, even if the lands are owned by multiple owners.
  - *Timing and Cost Considerations.* Purchasers can immediately begin evaluating and comparing their suppliers on the basis of the leadership, commitment and cooperation suppliers demonstrate to implement management planning at the landscape level. Progress in achieving the desired changes in forest management at this scale is likely to be more incremental.

    Whether significant costs will be incurred by implementing this measure will depend primarily on what changes result in management methods employed by the supplier and other landowners. Whether these management changes lead to increased costs will be determined by the factors already discussed above.

Recommendation 10. Purchasers should demonstrate a preference for paper made by suppliers who show environmental leadership by actively promoting efforts to manage non-industry lands (both public and private) so as to maintain and enhance the extent and environmental value of the nation's forestlands. Suppliers should actively support and encourage management of such lands using non-intensive approaches so as to provide and preserve ecological values that are more limited or difficult to provide on more intensively managed industry lands.

- *General rationale for recommendation.* Many companies in the forest products industry point to the need to rely on public and non-industry private forest (NIPF) lands to provide and preserve the full range of habitat and landscape diversity that they maintain is not possible or is far more difficult to provide on their lands. Ensuring that public and NIPF lands in fact serve this role requires that a different, less production-oriented type of forest management prevail on a substantial fraction of these lands, relative to the intensive management pursued on most industry lands. This is especially true in regions where such lands are relatively scarce or fragmented or where they harbor rare or natural communities or other ecologically important values (for example, wilderness).

  It also follows that the industry should be proactive in initiating, encouraging and supporting efforts to manage public and NIPF lands in ways that preserve all ecological values better than they maintain is possible for them to do. Only in this way can the potential be realized to reduce management pressures on ecologically important lands through intensive management of most industry lands. Translating this concept into reality may have very different implications with respect to future wood supply from public and NIPF lands; see below.

- *Timing.* Purchasers can immediately begin evaluating and comparing their suppliers on the basis of the leadership, commitment and cooperation suppliers demonstrate to encourage and promote these objectives. Progress in achieving the desired changes in forest management is likely to be more incremental. (See below for a discussion of cost considerations.)

- *Supplier implementation measure: Encourage reforestation, natural management on non-industry private lands.* Suppliers should encourage reforestation efforts on non-industry private lands, and promote natural forest management (including use of natural regeneration systems) and maintenance of natural biological diversity on such lands. These efforts should encompass lands of their own wood suppliers as well as members of landowner assistance programs. Suppliers should also support such efforts more generally, given that, in addition to enhancing their environmental value, management of such lands for some level of wood production can simultaneously provide a competitive return on investment for the landowner; enhance the wood supply; and reduce pressures to intensively manage more sensitive or ecologically valuable lands. Intensive management of some non-industry private lands (especially those in larger holdings), in addition to providing strong economic returns for the landowner, can be beneficial in terms of their contribution to wood supply. As with industry lands, however, such practices should be concentrated on already cleared and disturbed lands of relatively lower ecological value, such as abandoned agricultural lands, and should be avoided on more environmentally sensitive and valuable lands, in keeping with Recommendation 6 above.

  - *Specific rationale and cost considerations.* On non-industrial private lands, promoting reforestation of such lands to the greatest extent possible will have positive economic consequences for landowners and suppliers, by enhancing overall wood supply. Bringing non-forested lands into the forested land base through reforestation, and enhancing the quality of degraded forestlands through more active management, can also enhance the ecological values provided by such lands.

    For many non-industrial owners, less intensive management that uses natural regeneration and both even and uneven-aged systems can be economically attractive. Less intensive management generally results in lower volume yields than intensive management. However, the associated low input costs often produce economic returns that are at least competitive with high-input, higher-yield forestry.

    Use of less intensive management methods on many such lands, including promotion of increased acreages of natural forest through natural regeneration methods, and taking steps to ensure that landowners are managing their lands in compliance with BMPs and other appropriate safeguards, can further enhance the environmental values and functions served by such lands. Particularly in the U.S. South where the nation's pulpwood production is concentrated (see Figure 4), the considerable extent of intensively-managed industry holdings and the relative scarcity of public lands place even greater importance on the need to manage non-industry private lands so as to ensure maintenance of the full range of environmental values forests can provide.

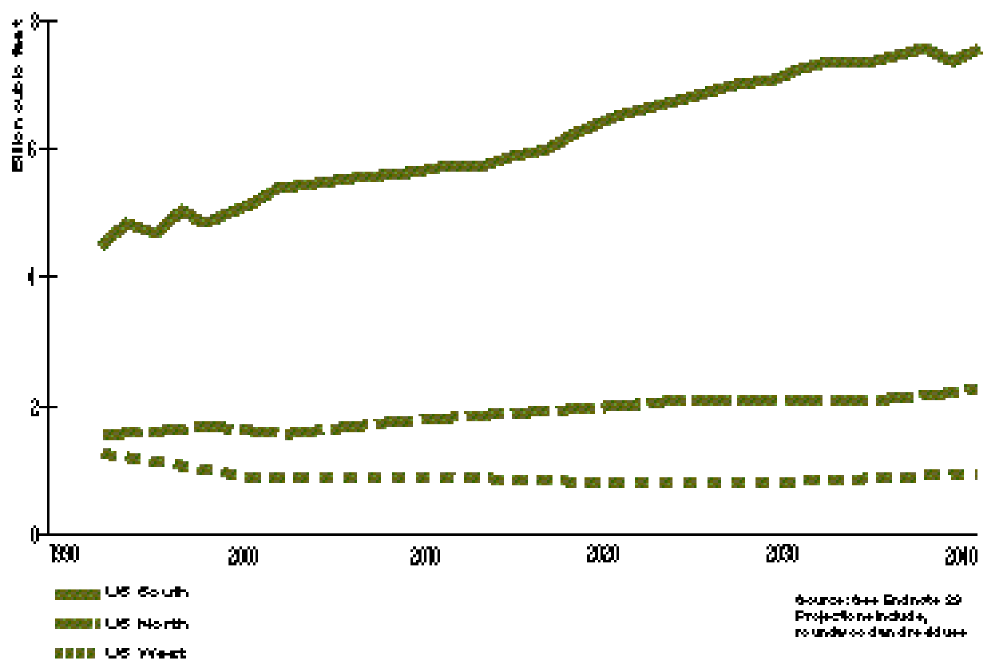
    The economics of forest management for industrial landowners are generally quite different. Forest products companies typically utilize intensive management on their own lands as a means to reduce pulpwood procurement costs for their processing facilities. These capital-intensive mills require a continuous flow of pulpwood. Non-industrial private landowners, on the other hand, have a broader range of objectives in managing their lands.

- *Supplier implementation measure: Lessen reliance on wood from ecologically sensitive or valuable public lands.* Suppliers should reduce their reliance on wood harvested from public lands in areas or under conditions where their management for such purposes reduces the extent of, or the ecological, recreational and aesthetic values provided by, natural forest communities. This concern is particularly important in regions where public lands represent a relatively small proportion of total forestlands (for example, in the Southeast) or where public lands harbor most or all of a unique forest community or ecosystem (for example, remaining old-growth forests in the Pacific Northwest).

  - *Specific rationale and cost considerations*. For public lands, especially those that are particularly environmentally sensitive or important, a lessening of management intensity and

Figure 4

U.S. Pulpwood Supply
by Region, 1992-2040



harvest levels, and hence wood production, is desirable. Avoiding intensive even-aged management will help to maintain a full panoply of types and stages of natural forests and their associated habitats, including greater representation of mature and old-growth forests and large contiguous areas of minimally disturbed forest. Production-oriented management should be avoided entirely on lands that represent important ecological values (for example, rare or declining natural systems). Such measures are more paramount where public lands are relatively scarce or fragmented, or where they hold important reserves of remaining natural communities (for example, old-growth forest in the Pacific Northwest).

Most timber harvests from public lands in the U.S. are conducted primarily for the purpose of producing sawtimber rather than pulpwood; by-products of this primary activity, in the form of residuals from sawmills, thinnings and final harvest of trees not suitable for sawtimber, provide most of the pulpwood harvested from these lands. Hence, pulpwood production is not the major economic driver of harvests from public lands. Nevertheless, because many forest products companies harvesting from such lands operate facilities that produce or consume both sawtimber and pulpwood, and because in the aggregate pulpwood is a significant, if minority, economic component of such harvests, the issue of timber harvests from public lands is germane to paper purchasers.

Reductions in harvests from public lands have been underway for a number of years, especially in the West, as a result of intense public debate. Many forest products companies have already reduced or eliminated their reliance on such supplies; for them there will be few or no direct cost implications from implementing this measure. Moreover, most U.S. pulpwood is now produced in the South, where public lands are relatively sparse. Finally, because public lands are typically managed on longer rotations than are industry lands, sawtimber — not pulpwood — is the primary output. Combined, these factors argue that implementation of this measure should have relatively little impact on suppliers' costs for pulpwood.

Assessing the full effect of further reductions in wood supply from public lands on overall pulpwood market dynamics and paper supplier costs is enormously complex and beyond the scope of this project. (See White Paper No. 11 for further discussion of timber and pulpwood supply, demand and cost trends.)

III. PURCHASER IMPLEMENTATION OPTIONS

There are a number of actions, ranging from very proactive to relatively passive, that paper purchasers can take to influence forest management on industrial, non-industrial and public lands. We recognize that there are many different types of purchasers and purchasing relationships, and that only some of these actions can be taken by a given purchaser. We also recognize that the issues addressed in the recommendations are complex and likely new to most purchasers. For these reasons, we have proposed a menu of implementation options from which a given purchaser might choose.

The following options are grouped into five categories and arranged in order from least to most proactive. Table 1 displays these options in a form that can serve as a tool for purchasers in choosing which of these approaches they wish to employ to implement each recommendation. Different purchasers may choose to begin implementation at different "tiers" within this spectrum of options. Or a purchaser might choose to start at a relatively low tier, and move to higher tiers over time.

Dialogue with Suppliers

Implementation option: Ask the producer/supplier to explain what it is doing to address the recommendation(s).

Purchasers may be able to influence some forest management practices simply through educating themselves and asking the right questions. Emphasizing to the supplier that forest management is of concern and is relevant to your purchasing decisions will ensure that forest products companies are at least aware of their buyers' concerns.

Under this strategy, paper purchasers would ask specific questions of forest products companies relating to forest management practices. For example, is your company actively converting natural forest systems to plantation management? If so, what is your company doing to mitigate against the adverse environmental impacts? To aid the purchaser, the Task Force has developed several sets of questions that can be used to explore the performance and practices of a supplier as they relate to some of the key objectives of the Task Force's recommendations; these questions are provided in the Appendix.

Periodic Reporting

Implementation option: Request that the supplier periodically provide information in writing describing its activities to address the recommendation(s).

This approach can increase the seriousness with which the supplier will address your concerns, and provides a record of their responses to you. More proactive purchasers could seek to evaluate the company's information through additional means (for example, use of an independent expert).

Even in the absence of such expertise, such reporting can provide the purchaser with a basis for evaluating the information, by allowing comparison of the report from one supplier with those from other companies, or comparison of the same supplier over time using successive reports prepared at appropriate intervals (for example, annually). It may be useful for purchasers to develop and ask suppliers to use a common format for the reports, in order to facilitate such comparisons. The purchaser may also wish to ask suppliers to include in their reports written answers to the sets of questions provided in the Appendix.

Purchasers should emphasize to their suppliers that forest management is of concern and is relevant to their purchasing decisions.

Requiring periodic reporting (for example, annually) further formalizes the information exchange and facilitates comparison of a given supplier's activity over time. Under the Sustainable Forestry Initiative, AF&PA members are required to submit annual reports to the AF&PA describing their plans and procedures for implementing the SFI principles and guidelines. Purchasers should request to receive copies of the materials prepared and submitted each year by suppliers who are AF&PA members.

Goal-setting

Implementation option 1: Ask your supplier to set goals for advancing specific supplier implementation measures, and to report to you on progress toward that goal.

For example, a goal might entail specifying what fraction of all harvests from the company's lands comply with voluntary Best Management Practices (BMPs) applicable in the jurisdiction in which they occur, or what fraction of pulpwood purchased from other lands was harvested from lands that were managed in compliance with BMPs. Each goal should be accompanied by a date certain by which it would be met, and a clear method for measuring compliance.

Implementation option 2: Working either with or independent of your supplier, set your own goal and timetable for improvement in the supplier's performance on one or more recommendations.

Require your supplier to meet a goal or target that *you* set or help to set, and communicate it as a factor in or condition of your continued business with the supplier.

Implementation option 3: Set an initial goal, and ratchet it up over time.

For example, you might initially set a goal that requires a modest level of compliance with a desired recommendation, for example, the fraction of purchased pulpwood harvested by certified loggers. By clearly communicating to the supplier the initial goal and your intention of (and timetable for) raising it over time, you can spur efforts toward continuous improvement while addressing the understandable concern that applies in many cases that implementing a desired change cannot be done all at once.

Purchasing Conditions

Implementation option 1: Require, as a condition of your purchase, compliance of the supplier with specific standards or guidelines set by the forest products industry or others.

For example, purchase only from suppliers who comply fully with the Sustainable Forestry Initiative of the American Forest & Paper Association, and with all BMPs applicable in the jurisdiction(s) in which they operate, even where the BMPs are voluntary. This step may entail imposing new requirements on your existing suppliers, with a timeline for compliance, or identifying new suppliers that already meet, or are committed to meeting, the stated objective.

Implementation option 2: Encourage or require efforts on the part of a supplier that go beyond compliance with established standards.

Purchasers could ask that companies strengthen certain components of the SFI or BMPs. For example, purchasers could ask that pulpwood used to make their paper products be harvested only from lands where streamside management zones (SMZs) are placed along all intermittent as well as perennial streams.

Auditing/Certification

Implementation option 1: Require your supplier to audit and/or certify compliance with a condition you seek to apply to your purchases.

These mechanisms add credence to suppliers' claims by requiring proof of compliance with a condition and making their statements legally binding.

Implementation option 2: Examine, audit or certify the practices of interest yourself, for one or more actual or potential suppliers.

Purchasers taking this approach would hire in-house staff or consultants to examine all or specific forest management practices of suppliers. This could entail visits to company lands, examination of company relationships with private landowners and loggers, and other information gathering to "rate" the practices of individual companies. Staff/consultants could work with suppliers to improve forest management practices, if necessary.

Implementation option 3: Require suppliers to provide independent certification of their practices, or to purchase products that come only from certified forest management operations or companies.

Under this strategy, purchasers would request that forest products companies have their operations certified by an outside organization. There are already a few large landowners that have had lands certified by third-party organizations. It is important to note that the reliability of such certification activities and organizations is the subject of considerable debate. As with other strategies, purchasers who choose to actively work to understand the certification process and help to establish or select certain minimum standards will likely have a greater influence over forest practices.

IV. ENVIRONMENTAL AND ECONOMIC FINDINGS

A. Environmental Findings and Summary of Support

This section presents the Task Force's key findings on the environmental impacts of forest management, along with a summary of the support for those findings. These findings are taken directly fromWhite Paper No. 4 (contained in Volume II of this report), which develops the findings in more detail and provides references to supporting documentation.

Findings on Forest Management in General

1. State-level Best Management Practices (BMPs) to mitigate the impacts of forest management on water quality are substantial and widespread.[26] Their effectiveness, however, is not universal.

- Generally, full adherence to BMPs can effectively minimize soil erosion and stream sedimentation from forestry activities. However, the level of coverage of BMPs varies among states; some states allow activities that may not fully alleviate water quality concerns. While BMPs generally include streamside management zone recommendations or requirements, for example, several states do not requires such measures at all on intermittent streams.
- All states with significant timberland area have some form of forest practice legislation or regulation specifying BMPs. In general, BMPs are voluntary throughout the South and in some northern states, and are mandatory in western states.
- In the South[27], BMP compliance generally is highest on public lands, usually followed by lands owned by the forest products industry and large holdings of non-industry private landowners. Small non-industry privately-owned lands generally show the lowest compliance rates. Despite reported high overall compliance rates, recent compliance surveys have identified significant non-compliance in all ownership categories with key BMPs, such as those governing skid trails and stream crossings.

2. Few regulatory measures have been adopted to protect forest values other than water quality.

- Outside of the Pacific Northwest, state-level forest practice regulations are designed to protect water quality, and only incidentally may protect wildlife habitat (other than certain aspects of fish habitat), natural communities, long-term soil productivity and other forest values.
- Federal laws, such as the Endangered Species Act and the Clean Water Act, provide some regulation of private as well as public forest management with respect to wildlife and forested wetlands. However, their scope is limited — for example, the ESA only governs impacts on particular species listed as threatened or endangered — and they do not offer comprehensive consideration of wildlife diversity or natural ecosystem protection.

3. Numerous voluntary efforts have been made on the part of forest products companies and the forestry profession to address environmental concerns. For example:

- The American Forest & Paper Association's (AF&PA's) recently adopted "Sustainable Forestry Principles and Implementation Guidelines" designate important environmental objectives for its member companies, including: the maintenance of habitat diversity at a landscape scale; use of management techniques to protect wildlife habitat, such as riparian and wildlife corridors; the responsibility of forest products companies to encourage their wood suppliers to manage forests more sustainably (see below); and the need to protect biologically and otherwise valuable sites. In most cases the guidelines provide that each company design its own method of implementation to meet a goal, rather than setting a specific performance standard. This approach may make assessing compliance difficult.
- In addition to these guidelines, some forest products companies

have individually committed resources to environmental measures such as landscape management, environmental auditing, company-specific BMPs, special area programs, logger training and landowner assistance programs. An assessment of the effectiveness of these efforts is beyond the scope of this paper.

- Finally, a controversial report issued by the Society of American Foresters (SAF) has advocated a shift from traditional sustained-yield forest management to ecosystem management as a means of achieving sustainable forestry.

Findings on Potential Environmental Impacts and Mitigation Measures

4. The potential adverse environmental impacts of most concern are the cumulative impacts of forest management activities over time and on a scale larger than that of a particular activity conducted in a particular stand of trees.

- Cumulative impacts can develop over the long term or can arise in shorter time spans from several distinct activities. Some cumulative impacts, moreover, may arise from activities that may not appear significant at a local scale, but which are significant at a landscape level.
- Potential impacts include:

A. *Impacts on soils and forest productivity.* Repeated intensive harvesting on short rotations (especially of whole trees) may deplete nutrient levels over the long-term and, on nutrient-poor sites, potentially may impair **forest productivity** — not only of crop trees but of the forest as a whole. Some methods of site preparation — in particular, methods that disturb the soil or remove logging slash and debris — may also have adverse effects on forest productivity by displacing nutrients from a site.

Mitigatory measures include identifying nutrient-poor sites and altering management practices in such areas.

B. *Impacts on forest streams.* When performed without safeguards such as adequate buffer strips along streams, certain forest management practices can impair **aquatic habitat** for many species:

–Deposition of sediment in streams can result from forest management practices that increase soil erosion by disturbing forest soils and/or increasing water runoff.

–Stream chemistry can be altered by the use of fertilizers or pesticides, or by harvest-induced increases in nutrients leached from the soil and flushed into streams.

–The removal of trees adjacent to streambanks can affect the physical structure of a stream, weaken streambanks, and elevate water temperatures.

–The potential also exists (where proper measures are not taken) for certain forest management practices to degrade drinking water quality. However, the drinking water quality of water from forested watersheds generally is very high.

Among the most important mitigatory measures to ensure protection of water quality is the use of **streamside management zones (SMZs)**: low- or no-management buffer strips maintained along streams to filter out sediment and nutrients, maintain shade, and provide other benefits such as supplying dead logs and limbs for physical structure. In particular, effective use of SMZs requires that they:

–be maintained along intermittent as well as all perennial streams;

–be sufficiently wide to function as effective filters; and

–for perennial streams, include enough continuous forest cover to ensure shading and a supply of limbs and logs sufficient to maintain natural stream structure (where appropriate).

Although virtually all state BMPs include streamside management zones, few specify all of these important conditions.

C. *Impacts on plant and animal habitat and species diversity.* Forest management potentially can have both direct and cumulative effects on plants and animals. The cumulative effects, which result from changes in vegetation as a result of forestry activities, are more significant.

–The use of insecticides and herbicides can have direct effects on wildlife. Significant adverse effects of pesticide applications on wildlife have occurred in some cases; however, the infrequency of application and the use of mitigatory measures lessen the risks.

–Forest management typically alters the **species composition and physical structure of vegetation** at a stand level. At a landscape scale, these changes in stand structure have significant cumulative impacts on plant and animal habitat.

–At a landscape level, maintaining forest animal diversity depends on maintaining an adequate **range of habitats**, from early-successional forest to mature and old-growth stands. Because trees in conventionally managed forests are harvested before they reach maturity or mortality, however, managed forest landscapes typically lack areas of mature and old-growth forest.

–Even-aged management, moreover, may also **fragment the forest**, adversely affecting populations of certain animal species that require large areas of contiguous forest. Many of these species are regionally or globally endangered, whereas those species that tend to benefit from such fragmentation (i.e., species that inhabit forest edges or other disturbed areas) are generally more common, in large part because such habitats are more readily available in human-disturbed landscapes.

Within the matrix of forest managed for solid wood and fiber production, **measures to mitigate these potential impacts** include:

–identifying areas of habitat for important plant or animal populations (for example, endangered species) and employing management practices that maintain or even enhance this habitat. For species associated with natural ecosystems or with mature forest, this means avoiding clearcutting in some areas, lengthening rotations in some even-aged stands, and allowing some trees to reach old whether in predominantly even- or uneven-aged stands;

–maintaining extensive **wildlife corridors** to provide connectivity among larger forest preserves or remaining blocks of contiguous forest in the landscape;

–retaining important **habitat elements** such as snags (dead standing trees) and old live trees; and

–maintaining **natural tree species diversity**, through means such as management for multiple tree species and wood products.

Landscape-level management has also been adopted in some form by several forest products companies, and has been advanced in principle by the Society of American Foresters and AF&PA. The level of detail and the specific provisions and management activities involved vary considerably among these initiatives.

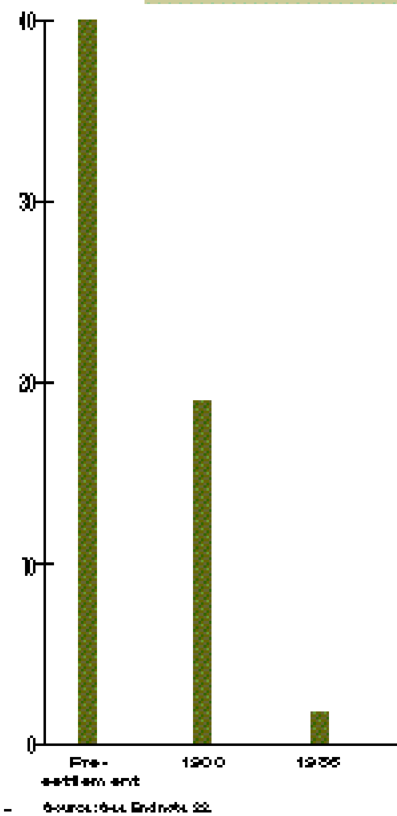
Findings on Natural Communities

5. At a landscape or regional scale, intensive forest management has contributed and continues to contribute to reductions in the extent of certain rare ecosystems and natural communities.

- Although urban and suburban development is often the major cause of losses of natural communities and ecosystems, forest management — particularly clearcutting followed by plantation establishment — can degrade or eliminate the functions and values (including wildlife habitat) provided by certain rare or dwindling ecosystem types, threatening their continued existence. Examples of such areas include:
  - –*longleaf pine forests*, which once covered the southeastern coastal plain but are now reduced to a fraction of their original expanse (**Figure 5**[28]), in part because of conversion to plantations of other pine species (for example, slash pine, loblolly pine);
  - –*old-growth forests* of the Pacific Northwest, especially the temperate rainforests along the Pacific Coast from northern California through British Columbia, which have been prized for their high-quality timber but have been vastly reduced in extent, threatening the forest type and the species it supports; and
  - –*some types of forested wetlands* that are both rare and candidates for forest management, including some classes of bottomland hardwood forests in the South and pocosins in coastal North and South Carolina.

Figure 5

Longleaf Pine Forest as a Percentage of the Southeast Coastal Plain



Findings on Management Activities of Special Interest

6. Clearcutting and alternative harvesting methods: Th logical effects of clearcutting vary widely among di

regions and depend greatly on site conditions. Its potential impacts, moreover, are of greater environmental concern in natural forests than in plantations or reforested marginal lands. In general, the effects of clearcutting are more likely to be acceptable: where large-scale disturbances were (or are) features of natural forests; where site conditions capable of inducing its potentially severe adverse effects are not present; and *where measures are taken to mitigate the effects of clearcutting on wildlife.*

- Forest managers employ clearcuts when the tree species desired for the new stand is (are) intolerant of shade. Clearcutting is also an efficient harvesting method. Where intensive plantation management is employed, clearcutting facilitates planting, which may lead to significant increases in yield that can be further enhanced through the use of genetically selected seedlings and stocking control.
- By removing all or most trees in a stand, clearcutting can increase windspeeds and soil temperatures and alter soil moisture levels. The consequences of these physical changes depend heavily on the forest type and on site conditions, but potentially include significant impacts on the forest values presented above: forest soils and productivity; water; plant and animal habitat and diversity; and natural communities.
- Whether clearcutting is an appropriate harvesting method on a given site or in a given region depends on both silvicultural and environmental considerations:
  - –The suitability of clearcutting as a silvicultural system varies by region and forest type. Where clearcutting emulates the scale, frequency and other aspects of the prevailing natural disturbance pattern — thus ensuring that the regenerating forest will be suited to the site — it may be silviculturally appropriate.
  - –The environmental impacts of clearcutting can be severe and unacceptable on some sites: where severe soil erosion is likely; where regeneration of a new stand may be impaired as a result of exposure to extreme climate or changes in populations of soil microorganisms; along streams and other waterbodies; and on lands harboring important plant and animal populations, such as endangered species habitat and rare natural communities.
  - –On sites where clearcutting is employed, limiting the size and frequency of clearcuts, carefully managing their placement within the landscape and retaining structural elements such as some live trees, snags and downed logs can mitigate some of the potential adverse effects of clearcutting on wildlife habitat.

  On relatively flat sites with stable soils and rapid revegetation after disturbance, in operations where adequate consideration is given to regeneration and to maintenance of stand structure and overall landscape diversity, clearcuts of modest size and frequency may be environmentally acceptable.
- *Alternative harvesting/regeneration methods*, if properly employed, generally are less environmentally stressful than clearcutting, although they do have some significant potential drawbacks relative to clearcutting.
  - –Shelterwood cuts, by maintaining a degree of forest influence in the cut-over area, disturb the forest, soils, and wildlife less than clearcutting. On the other hand, the typical practice of subsequently removing the initially retained trees renders this method effectively a form of even-aged management, accompanied by the same cumulative effects such as forest fragmentation and the loss of mature forest.
  - –Selection cuts (including group and individual-tree selection) maintain greater wildlife habitat and structural diversity in the forest; moreover, selection cuts are not associated with intensive site preparation and its attendant potential impacts on soil productivity, integrity and structure. However, selection cutting potentially has adverse environmental effects, the most significant of which results from its most common misapplication, termed "high-grading," in which only the best-quality trees in a stand are harvested, leaving a low-quality stand.
  - –In regions historically subject to relatively frequent large-scale natural disturbances (for example, wildfires), natural stands may be dominated by shade-intolerant tree species. Use of selection cutting, combined with fire suppression, could convert such a stand into one dominated by shade-tolerant species if harvest openings are not large enough to permit direct sunlight to reach the forest floor, while clearcutting would be more likely to regenerate a new stand more closely resembling the original stand.
  - –Selection cutting may require more frequent entries into a stand than even-aged systems, increasing road and skid trail use and the frequency of forest disturbance. However, this

disturbance typically is of less magnitude than the disturbance from a clearcut; moreover, the frequency of stand entry in highly intensive, even-aged plantation management may approach that of a selectively harvested stand

- Depending on forest type and site conditions as well as the intensity of management, yields from uneven-aged management in some cases can be comparable to yields from even-aged management. For example, uneven-aged management with frequent stand entries in spruce-fir forests may produce higher timber growth and yield than low-intensity even-aged management (i.e., clearcutting and natural regeneration). As conventionally practiced, however, even-aged management employing clearcutting is more commonly associated with highly intensive, high-yield methods of silviculture, while uneven-aged management is typically much less intensive. This distinction is especially valid in the South, where intensive even-aged management practices on pine plantations produce sizable gains in yield. As a result, uneven-aged management generally requires a larger land base than intensive even-aged systems to produce the same amount of wood.

7. Artificial regeneration and monocultures: The establishment of monocultures through artificial regeneration need not be an environmental concern per se. Although the monocultures established by artificial regeneration usually are simplified compared to natural stands, this simplification stems from other forest management practices in addition to the planting of a single species. Furthermore, where reasonable precautions are taken, the impact of genetically selected seedlings on genetic diversity does not appear to be a serious concern at the stand level. The overall extent and placement of monoculture plantations in the landscape are the major determinants of their environmental impact.

8. Reforestation: The environmental impacts associated with tree plantations are determined by how and where plantations are placed in the landscape. In some cases reforestation, the establishment of forests (including single-species plantations) on currently cleared and nonforested lands, may be environmentally beneficial. Millions of acres of marginal or abandoned farmland may be suitable for reforestation and pine plantation establishment.

- The establishment of forests on already cleared and altered lands (for example, marginal agricultural crop and pasture lands) is environmentally preferable to further conversion of natural ecosystems to plantations. Indeed, reforestation of such lands may enhance their associated environmental values, while expanding the timberland base available for production of solid wood and fiber.
- Government-sponsored reforestation programs, such as the Conservation Reserve Program, have enjoyed some success and have demonstrated the potential profitability of establishing production forests on marginal lands.
- The potential acreage amenable to reforestation is substantial. By one estimate, reforestation for softwood forests in the South alone would not only be possible but *profitable* on more than 19 million acres of marginal lands. Assuming average yields, this additional land area could increase the South's softwood harvests by nearly twenty percent over current production.

Establishing forests on already cleared marginal agricultural or pasture lands is environmentally preferable to further conversion of natural ecosystems to plantations.

B. Economic Findings and Summary of Support

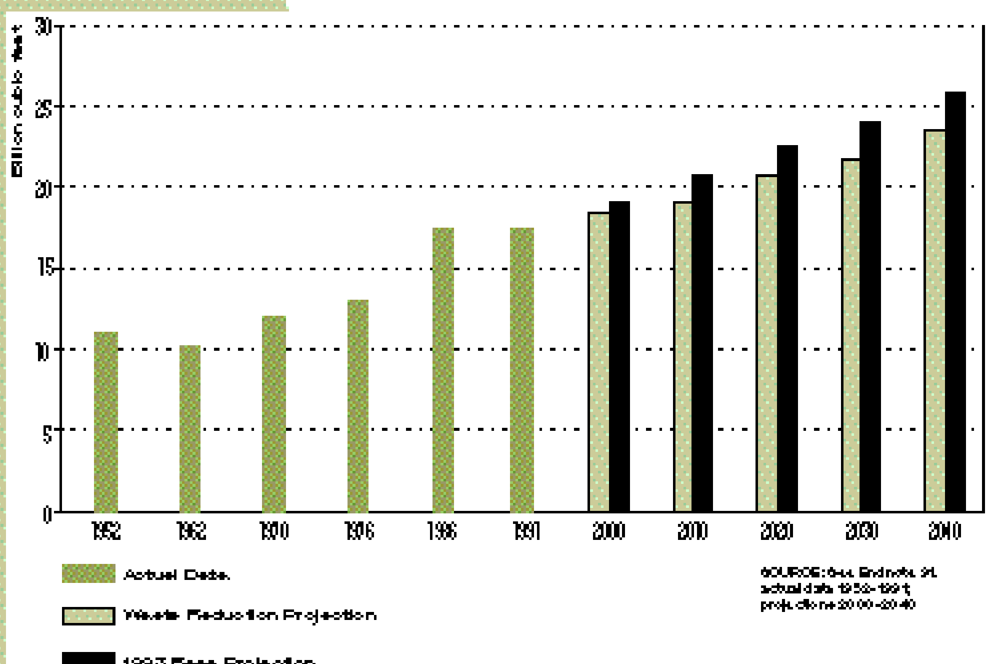
This section presents the Task Force's key findings on the economic considerations of forest management, along with a summary of the support for those findings. These findings are taken directly fromWhite Paper No. 11 which develops the findings in more detail and provides references to supporting documentation.

Findings on U.S. Timber Supply and Harvests, Pulpwood Supply and the Impact of Paper Recycling

[NOTE: Some of the following findings are based in part on data and projections of the USDA Forest Service's models of the North American forest sector.[29] This source represents the only publically available comprehensive information of its kind. Like all projection models, myriad assumptions have been made regarding future conditions affecting timber supply, the accuracy of which is not universally accepted among experts in the field. Where possible, we have supplemented the Forest Service a with information from other sources, most notably a rominent forecasting and economics consulting firms that specializes in the forest products industry, Resource Information Systems, Inc. (RISI).[30] While RISI's information is also not universally accepted among experts, we believe that the use of these data along

Figure 6

Projected Effect of Recycling on Total U.S. Timber Harvests



with those of the Forest Service reasonably represents the range of possible future outcomes and provides several important comparisons and contrasts on key points, as discussed in the body of this paper.]

Between now and 2040, U.S. timberland acreage is pro-1 to decline by roughly 5.5%, due almost entirely to losses :r uses of non-industry private lands.

This ownership class comprises more timberland than the public sector and the forest products industry combined. While industry holdings grew substantially (by 11.5 million acres, almost 20%) between 1952 and 1992, they (as well as public lands) are projected to remain fairly stable through 2040.

2. Despite the modest decline in timberland acreage, total *timber inventories are growing. However, a more constrained picture can be expected with respect to* available *timber, and hence, pulpwood supply.*

- The total *softwood* inventory is projected to grow 30% by 2040, mostly on public lands due in part to harvest reductions in the West. Increasing intensity of management on industry lands, especially pine plantations in the South, will also contribute to the increased softwood inventory. Slow growth is projected for total *hardwood* inventories: a 10% increase by 2040, all on public lands. Hardwood inventories on all private lands, especially those in the South, will decrease, primarily due to harvest levels that outpace growth to meet both pulpwood and fuelwood demand, and some conversions of hardwood forests (primarily upland) to pine plantations.
- A variety of factors act to reduce the inventory of timber available for harvest, including: reductions in allowable harvest levels on public lands due to environmental considerations, as has recently occurred on National Forest lands, especially in the West; regulatory restrictions on forest management, such as institution of Best Management Practices calling for the retention of buffer strips along streams; and voluntary reductions in management intensity or removals of forested areas on private lands, such as retention of wildlife corridors or donations of special areas to conservation organizations. Depending on assumptions made about these and other factors, estimates of *available* timber inventories and pulpwood supply can vary dramatically and are subject to considerable uncertainty.

3. Recycling will act to slow the rate of growth of pulpwood production and moderate overall timber harvests, rather than lead to an absolute decline. Increased recovery and recycling of paper will also have the effect of extending significantly the U.S. fiber base.[31]

By extending fiber supplies, recycling will help to sustain much higher export volumes of both pulp and paper and paperboard products and reduce the need for imports, making the U.S. more self-sufficient in fiber supply into the next century. However, as paper recovery rates reach their practical limits sometime in the next century, and as demand for paper and paperboard products, both at home and abroad, continues to rise, demand for pulpwood will "rebound," and hence pulpwood harvests are projected to increase substantially, albeit at a slower rate than without recycling. See Figure 6.

4. Southern states produce a commanding share of pulpwood and paper products, a share that is projected to grow substantially. Much of the South's timberland is geared towards pulpwood production, the region's leading timber product; favorable growing conditions and high forest industry ownership both help make intensive management possible. This emphasis on intense fiber production is also reflected in the increasing acreage of pine plantations across the South.

5. Pine plantations are projected to cover more acreage than natural pine in the South by the turn of the century, and by the year 2030, more than two-thirds of the region's pine forests (and over a quarter of all its timberland) is projected to be in plantations. These plantations are located primarily on industry land. (See Figure 7.[32])

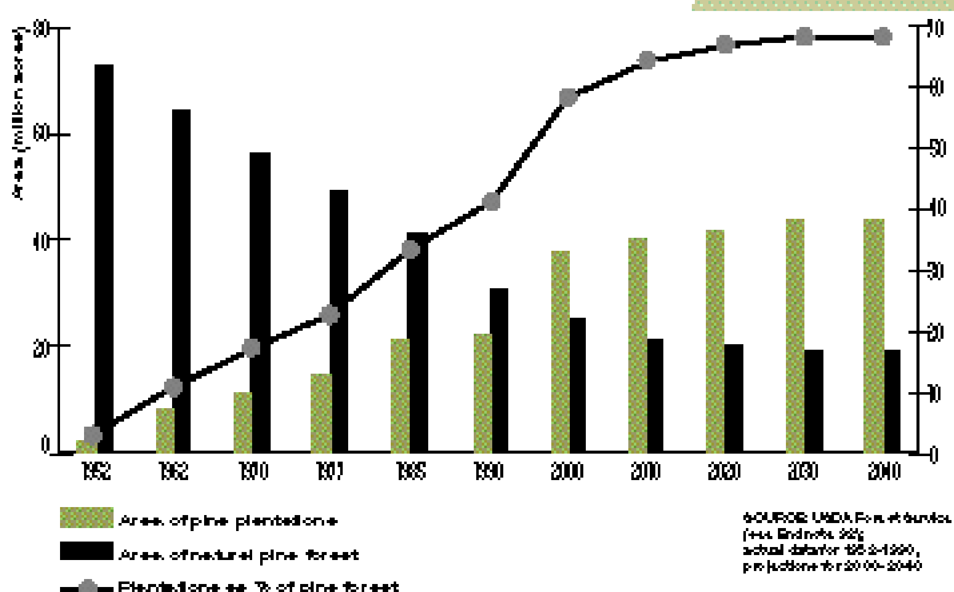
6. Most pulpwood originates from lands held by non-industrial private owners, in large part due to the fact that most timberland is in this ownership class. Combined with pulpwood originating from public lands, the great majority of pulpwood utilized by a typical pulp mill — about three-quarters on average — originates on lands (both public and private) other than those it owns.

Findings on Trends in Pulpwood Prices and the Impact of Recycling

7. In many regions, pulp and paper mills can exert considerable influence over the prevailing stumpage and delivered prices paid for pulpwood. The primary reasons for this are the large fiber requirements of many mills and the substantial costs involved in transporting pulpwood to other markets. Also, forest products companies may be able to affect stumpage and delivered prices thro modifications in harvesting practices or rates on compar lands. Thus, in some regions, paper companies do not exist in perfectly competitive markets.

Figure 7
Growth of Pine Plantations in the South

in Area and as a Percent of Pine Forest
Base Projection for 2000-2040



8. Increased recycling is expected to impart greater stability on pulpwood prices well into the next century than would otherwise be the case.

- USDA Forest Service projections indicate that, with the exception of softwood prices in the North, near-term (through roughly 2010) pulpwood prices will decline in all regions, reflecting the role that recov ered paper will play in extending the fiber base. As re cling rates begin to stabilize, however, pulpwood price begin to rise again as overall demand for pulpwood in

• Extending their pulpwood price projections to examine price trends for paper and paperboard products, the Forest Service predicts relative stability in paper and paperboard prices over the long term, largely attributed to the contribution of recovered fiber in extending the U.S. fiber base. The Forest Service argues that recent pulp and paper price hikes reflect a relatively transient effect of the industry's business cycle, rather than a more persistent response to a change in underlying demand.
• In contrast, Resource Information Systems Inc. (RISI) projects that both softwood and hardwood pulpwood prices will rise significantly over the next five years as a result of increased competition for virgin fiber. RISI projects that engineered wood products, such as oriented strandboard, which can be manufactured from small diametered trees and chips used traditionally for pulpwood, will markedly increase the demand for virgin pulpwood. However, RISI concurs with the Forest Service that increased recycling will place downward pressure on pulpwood prices.

9. Management practices and rotation ages are driven in large degree by the relative profitability of sawtimber versus pulpwood production.

Currently, management practices and rotations which favor sawtimber or multiple product outputs are typically more profitable than those favoring pulpwood alone. According to USDA Forest Service projections of future stumpage prices, this will continue to be the case for the foreseeable future as real sawtimber prices rise while pulpwood prices remain relatively stable. If true, management practices and rotations which favor sawtimber or multiple product outputs will likely be more profitable than those favoring pulpwood alone. However, RISI projects that prices for small diameter trees will increase dramatically as a result of the emergence of engineered lumber products while sawtimber prices will stagnate — at least for the short-term. If true, this will increase the profitability of short rotation forestry and pulpwood production. RISI's analysis suggests that the distinction between pulpwood and lumber projection from forest management will become increasingly blurred. The perspectives of various forest products companies and other experts differ as to which projection is more accurate.

10. Hardwood prices are projected to rise both in absolute terms and relative to softwood. This may make more intensive hardwood management, especially plantations, profitable. It may also improve financial returns from less intensive softwood management regimes that do not seek to suppress hardwood competition. Under such regimes, rather than requiring expenditures for competition control, hardwoods become an asset that can be sold as pulpwood (or fuelwood or sawtimber).

Findings on Economics of Pulpwood Production and Market Intervention into Forest Management Practices: Assessing Costs and Benefits

11. Non-industrial landowners and forest products companies tend to have different land management objectives.

• Non-industrial landowners who actively manage their lands seek to maximize a variety of timber or non-timber benefits from their forestland. Non-timber benefits such as wildlife habitat, aesthetics, and soil conservation are important management objectives for many non-industrial private landowners.
• Forest products companies manage land to produce pulpwood and sawtimber for mills as part of a broader objective to minimize total wood procurement costs.
• Forest products firms have a number of strategies they can employ to minimize their pulpwood procurement costs. Strategies include increasing supplies from company-owned lands through intensification of management, expanding their land base, or reducing sawtimber production in favor of increased pulpwood output. Forest products companies can also increase supplies from private lands by raising the delivered pulpwood price they are willing to pay or by entering into cooperative agreements with private landowners. Firms may utilize a number of these strategies to minimize procurement costs and ensure a steady fiber supply. In theory, forest product companies will seek to equalize marginal procurement costs across all sources of pulpwood.

12. Less intensive management can have financial returns comparable to or higher than intensive silviculture on non-industrial private lands.

In many cases, returns from intensive forestry do not justify high input costs associated with site preparation, competition control and plantation establishment, given that most non-industrial landowners do not have the same economies of scale and other cost advantages that forest products companies have. Less intensive silviculture also may provide greater non-timber benefits for non-industrial landowners.

13. For forest products companies, intensive management which maximizes yields over short rotations is financially preferable to less intensive management, for a number of reasons.

- Forest products companies have significant capital investments in processing facilities with high fixed costs. Fiber shortages can be very costly if mills are forced to work at less than full capacity. Company-owned forestland, therefore, provides a reliable, nearby and high-quality source of fiber.
- Intensifying management on their own lands is a relatively inexpensive means for forest products companies to reduce total wood procurement costs because management inputs such as site preparation and competition control are a small proportion of total pulpwood production costs on company lands (see finding 14 below).
- Forest products companies have economies of scale that most other landowners tend not to have. These economies of scale result from larger, more homogenous management units, in-house management expertise and other factors.
- Transportation costs are reduced for wood harvested from company lands, which tend to be close to the mill.
- Forest products companies are more easily able to absorb the high input costs of intensive management relative to small non-industrial landowners.

14. An analysis of pulpwood production costs on forest industry land demonstrates that the costs of increased management intensity are a relatively small proportion of total production costs on industry lands — considerably smaller than the sum of expenditures for harvesting and transportation and land carrying costs. Southern pine plantation management and harvesting costs in 1992 dollars for forest products firms are estimated at $39-$85 per cord over the next three decades depending upon management regime, site productivity and other variables. The estimated future value of delivered pulpwood prices over that time period is $48-$94 per cord. The apparent gap between our estimates of production costs and projected future pulpwood prices is due to management and land carrying costs which are not accounted for in our estimate. The magnitude of these costs is difficult to estimate and will undoubtedly vary widely among firms and regions.

15. A broad range of costs and benefits (both to the affected landowner and to society at large) can be associated with forest management. The magnitude and distribution of these costs and benefits can be affected by regulation or incentives provided to landowners to affect changes in forestry practices. Quantifying their value is difficult and uncertain, however, making a traditional cost-benefit analysis exceedingly difficult to conduct.

- BMPs and other controls over forest management practices, especially those that lower yield per unit area and hence require landowners to invest more to maintain a given production level, have typically well-defined costs to affected landowners.
- Based on a review of several studies, compliance costs associated with BMPs typically amount to a few percent of gross revenues. Streamside management zones (SMZs) are among the least costly and most effective BMPs.
- Numerous examples have been identified in which BMPs and related measures also produce **economic benefits** to the same landowners, benefits that sometimes outweigh the costs. However, the relative sparsity of efforts to identify such benefits and the highly site-specific nature of the costs and benefits involved, preclude any broad generalizations about the *net* costs to landowners from BMP implementation.
- Landowners have responded to government-sponsored reforestation incentives. The impacts of cost-share programs on aggregate social welfare is difficult to judge, however, in large part because of the difficulty in measuring the resulting non-timber benefits that accrue to landowners and society at large under such programs.
- Through its effects on functions of forests, forest management can produce significant costs to society as a whole, by lessening or eliminating the environmental benefits normally associated with forests. These costs are considered negative externalities because they generally are not accounted for in the market. They include both quantifiable costs to commer-

cial entities, and broader social costs that are far more difficult to assess. Measures taken to limit the impact of forest management on forest functions can lessen or eliminate these costs.

- Forest management can also produce substantial social benefits. These benefits derive both from the presence of forests themselves (such as recreational opportunities and carbon sequestration), as well as from actions taken by forest landowners (such as land donations and forest research). Like social costs, the value of many such benefits may be difficult or impossible to quantify.
- Reforestation of degraded forest land and/or abandoned agricultural land could benefit both the environment (by restoring forest habitat) and the forest industry (by increasing the available timber supply). Also, utilization of less extensive forest practices on non-industrial forest lands in urbanizing areas (where intensive practices such as clearcutting can be visible and controversial) may help maintain land in forest (rather than in urban uses) and sustain timber supplies from these urbanizing areas — at least temporarily.

Clearcutting, unlike natural disturbance, removes most or virtually all of the timber from a site.

ANSWERS TO FREQUENTLY ASKED QUESTIONS

This section is intended to aid the purchaser by providing information on commonly discussed issues in a question-and-answer format.

1. Are we cutting trees faster or slower than they are growing back?

At a national level, the inventory of timber is increasing, for both softwoods and hardwoods. At a regional level, however, important differences are apparent.

- In the West and North, growth rates for both softwood and hardwood currently exceed harvest rates, and are projected to do so for the next five decades.
- In the South, however, where most pulpwood production is centered, a less sanguine picture is seen:
  - Softwood harvest rates currently exceed growth by about 10%. This situation is expected to improve somewhat in the next decade, however, with the increasing growth on industrial pine plantations more than offsetting the projected continued decline of softwood inventories on non-industrial private lands.
  - Hardwood growth rates currently exceed harvest by a considerable margin, about 50%. This situation is expected to reverse itself in the coming decades, however, as demand for hardwood pulpwood and sawtimber increase; the rate of harvest is projected to exceed growth by 2010. Harvest rates are projected to exceed growth by a substantial margin on both industrial and non-industrial private lands; while growth on public lands will exceed harvest, such lands contribute a relatively small amount of the total hardwood inventory in the South.

2. Isn't clearcutting just like a natural disturbance?

Some forest managers and wildlife managers regard clearcutting as a method of imitating large-scale natural disturbances, such as windthrow or stand-replacing fires. They argue that the use of clearcutting is environmentally well-suited to areas (such as the southeastern coastal plain) that were dominated by large-scale natural disturbance patterns before settlement by Europeans. However, one crucial difference must be pointed out: clearcutting, unlike natural disturbance, removes most or virtually all of the timber from a site. Moreover, what remains may be chopped, removed, or displaced by site preparation, which is made possible by clearcutting. As a result, clearcuts generally lack most or all of the important "biological legacies" typically found after natural disturbance, including scattered remaining living trees, snags and downed logs and limbs.

Furthermore, clearcutting typically occurs in a predictable pattern over a landscape, affecting every stand at regular intervals — dramatically different from natural disturbance patterns, which may vary greatly in frequency over a landscape, returning to some areas more than others due to chance or site conditions such as topography, soil moisture, and so on. The result, in natural forests, is a complex arrangement of differently sized and shaped patches, varying in species composition and age — a striking contrast to most even-aged forests. Finally, the prevailing natural disturbance regime in many regions (such as the Appalachian and northern hardwood forests) was likely the creation of small canopy gaps as single trees died. Such "gap dynamics" occurred at much more localized temporal and spatial scales than clearcuts.

3. Can clearcutting be an acceptable practice under any circumstances?

From a silvicultural standpoint, clearcutting may be necessary to ensure regeneration of several commercially valuable species — including some hardwood species as well as some softwoods, such as lodgepole loblolly pine in the West — which grow poorly in shade but generally grow very well when exposed to full sunlight. Where such *shade-intolerant* species are desired, clearcutting is often used to favor their regeneration. Moreover, by removing the forest cover, clearcutting makes planting possible, which also helps to ensure the successful establishment of a new stand. In addition to these silvicultural reasons, clearcutting provides considerable economic efficiencies, both in the harvesting operation itself and in the growth of the next stand.

While it offers silvicultural and economic advantages, clearcutting also raises a number of potential environmental concerns, which follow from the removal of most or all of the forest cover at one time. The removal of the forest cover alters wind patterns, soil temperatures, and soil moisture, changes which in turn can drive other potential environmental impacts, both cumulative and acute, on forest soils and productivity, forest water, plant and animal diversity, and natural communities.

The actual ecological effects of clearcutting vary widely among different regions and depend greatly on site conditions. Its potential impacts, moreover, are of greater environmental concern in natural forests than in plantations or reforested marginal lands. In general, the effects of clearcutting are more likely to be acceptable where:

- large-scale disturbances were (or are) features of natural forests;
- site conditions (e.g., highly erodible soils, steep terrain, extreme climate that can impair regeneration) capable of inducing its potentially severe adverse effects are not present;
- lands do not harbor important plant and animal populations, such as endangered species habitat and rare natural communities;
- the practice is avoided along streams and other bodies of water;
- the size and placement of clearcuts is carefully managed to enhance diversity in the age and vertical structure of trees across stands; *and*
- measures, such as retention of some live trees, snags and downed logs are used to mitigate some of the potential adverse effects of clearcutting on wildlife habitat.

4. Aren't plantations of trees just like a form of agriculture?

Plantations, or "tree farms," are generally made up of exclusively or predominantly one species of tree (most often softwood), all initiated and later harvested at the same time; in these respects, they resemble typical agriculture. Whereas most agricultural crops are annual, however, rotation ages for tree plantations span many years, ranging from as few as 7-10 years for eucalyptus in Latin America or cottonwood in the Mississippi delta, to 20-35 years for pine in the South and aspen in the North, to as long as 50-80 years or longer for softwoods in the North and West. As a result, the frequency of entries and the extent of soil disturbance and the use of fertilizers and pesticides are far smaller in plantation silvilculture than in agriculture. This also means less potential for impacts on water quality and soil productivity.

Tree plantations, with an age and structural diversity that is simplified relative to natural forests, nevertheless provide considerably greater plant (understory) and animal diversity and habitat value, as well as other benefits such as recreation and watershed protection, than do agricultural areas.

In another sense, however, the analogy between plantation silviculture and agriculture illustrates an important point: we should not expect to be able to rely on tree plantations for many of the environmental values associated with natural forests (see next question below), just as we do not expect endangered species habitat to be provided by corn fields. In each case, the *primary* value is in providing an economic good. At the same time, the nature of growing trees is such that greater environmental value is provided by a tree plantation than could ever be expected from an agricultural field. If managed to enhance such values within the framework of its primary role of enhancing the yield of forest products, *and* if it is not placed in environmentally sensitive or valuable areas, a tree plantation can provide both environmental and economic benefit.

5. How do plantations compare environmentally to natural forests?

Tree plantations have both beneficial and adverse environmental consequences relative to natural forests. On the one hand, plantations tend to provide less habitat value and exhibit lower biodiversity than natural forests. The intensive practices employed in typical plantations tend to hasten or eliminate the earliest successional stages of a forest and truncate (by harvesting) the more mature or old-growth stages of stand development. Even where the number of plant or animal species may be comparable or even higher in a plantation, the presence and abundance of rarer species tends to be lower than in a natural forest.

On the other hand, plantation management is typically conducted using a suite of highly intensive activities such as genetic selection, planting, stocking control, thinning, fertilization, and herbicide use, which together boost yields of solid wood and fiber. The higher yields per unit area afforded by the most intensive management systems could, at least in principle, reduce the total amount of forest area under management for solid wood and fiber production, potentially making more land available for the conservation of other important values such as wildlife habitat and wilderness. This benefit requires an explicit mechanism to translate the benefit of enhanced yield into a reduced intensity of management on more environmentally sensitive or valuable lands.

The extent of environmental impact associated with tree plantations is determined in large measure by how and where plantations are placed in the landscape. Where plantations are established in abandoned or marginal agricultural areas, they can enhance the environmental value of such lands. However, some plantations have been and continue to be established on ecologically sensitive sites such as forested wetlands and in areas where they replace rare natural communities, such as longleaf pine forests.

6. Does paper come from old-growth trees in the U.S.?

Very few old-growth trees in the U.S. are harvested expressly for the purpose of making paper. The reason is that such trees are far more valuable for use in solid wood products, primarily lumber. Sawmill residues, a by-product of lumber production, are in some cases used to make paper, however. In fact, these residues are the primary source of material used to make paper in the western U.S., accounting for over two-thirds of the region's pulpwood production in 1991.

7. How much paper comes from trees growing on public land?

In 1991, 18% of all timber harvested in the U.S. came from public lands. Unfortunately data do not exist that indicate what fraction of those harvests from public lands went to pulpwood versus other products. Because of the less intensive management and the longer rotations typically employed on public lands, however, one can surmise that, at least relative to industry lands, a disproportionately larger amount of harvests from public lands went to sawtimber and other solid wood products; this would suggest that somewhat less than 18% of all pulpwood was derived from public lands.

In the West, where a majority (55%) of timberlands are in public ownership, 45% of all timber harvests came from public lands. The majority of Western harvests (64%) went to sawtimber, with only 2.7% used directly for pulpwood and the remainder for other uses such as fuelwood and veneer products. These data do not include, however, the use of sawmill residues to make paper. In 1991, 68% of the West's total pulpwood production was contributed by such residues. In all, 11% of the West's harvests of growing stock were used as pulpwood.

Ninety percent of all wood harvested for pulpwood in 1991 came from the East, with the South accounting for 67% of all pulpwood harvests. Only 6.5% of all timber harvested in the South came from public lands. Timber harvest levels from public lands are projected to decrease during this decade in all areas of the U.S. The Forest Service projects that, by 2000, less than 13% of all timber harvested in the U.S. will be from public lands.

8. Why is biological diversity important?

Although the importance of productive forest soils and clean water are taken for granted, the importance of maintaining biological diversity is sometimes questioned by people who argue that the value of timber, or other natural resources important to humans, should take precedence over preserving the diversity of plants and animals that preceded us on the planet. Such arguments discount the identifiable benefits to humanity that are the fruit of biodiversity conservation. More importantly, however, conservation of biological diversity is fundamentally important in its own right.

Some reasons for conserving biodiversity include the economic and human-welfare benefits of protecting rare species: the diversity of species and of gene pools represents a storehouse of genes and chemical compounds for possible future use in applications such as the development of new medicines and pharmaceuticals and the engineering of agricultural crops resistant to drought, insects, or disease. The economic benefits, for society in general as well as for the biodiversity "prospectors" who identify useful genes or compounds, could be substantial. Examples already abound: a strain of wild grass that revitalized commercial corn agriculture in 1978; a tropical flower, the rosy periwinkle, that yielded the source of cures for Hodgkin's disease; and the Pacific yew, a tree native to some areas of the Pacific Northwest which is not highly valued for timber but contains a compound that holds promise as an anti-cancer drug. Many now-common foods were once discoveries: coffee, sugar, bananas, chocolate.

The diversity of life already provides a wealth of goods and services to humanity; in very real ways, the diversity of life underlies and supports our very existence, giving us air to breathe, enriching the soil for our crops, supplying natural resources for our shelter. Moreover, the visible support system of trees and crops and livestock is itself supported by a swarm of microorganisms, bacteria, little-seen plants and fungi. On a grand scale, biological diversity also holds out promise for future services: new food crops, medical miracles, fuel substitutes.

Although these discrete benefits are important in their own right, the economic value of biodiversity fails to provide the whole story. In *The Land Ethic*, Aldo Leopold (1949) made this point:

> 'A system of conservation based solely on economic self-interest is hopelessly lopsided. It tends to ignore, and thus eventually to eliminate, many elements in the land community that lack commercial value, but that are (as far as I know) essential to its healthy functioning. It assumes, falsely, I think, that the economic parts of the biotic clock will function without the uneconomic parts.'

At bottom, biological diversity is *inherently* important: it is among the defining elements of our world, and is the most essential piece of our collective heritage that we must pass on to coming generations. Its conservation reflects both prudence and a sense of respect for our surroundings and our origins.

> Biological diversity is *inherently* important: it is among the defining elements of our world, and it is the most essential piece of our collective heritage that we pass on to coming generations.

9. Are some species of animals and plants more important than others?

A sense of scale is important in evaluating this question: if an animal or plant, or an assemblage of animals and plants, is absent from a given stand of trees but is common in other stands in the region, it does not deserve the same protection or concern as a species that is regionally or globally rare. Thus, species that are rare on a global or broad regional scale are generally of higher conservation priority than species that are rare only at a local scale. A corollary to this principle is that more is not always better, from the point of view of species diversity, if rare species are being replaced by common ones.

As an example, consider even-aged forest management, including clearcutting, and the habitat types it creates across a forest landscape. Two arguments generally are invoked to support the proposition that clearcutting provides environmental *benefits*. First, the number of species on a recent clearcut can be higher than the number of species in a mature forest, and certainly higher than the number of species in a forest that has a closed canopy but is not yet mature. Therefore, a clearcut may increase species diversity on a given site. Second, a distinction can be drawn between the number of species within a stand and the number of species among several stands in the same forest. The number and relative abundance of plant and animal species in a particular forest stand — for instance, a mature forest — determine the species diversity in that stand. If more stands are considered — for instance, an early-successional stand, or a bottomland hardwood forest along a river — the diversity of species goes up, corresponding to the increase in species as more habitats are sampled. Because a clearcut stand represents early-successional habitat within relatively more mature forest, this line of reasoning concludes it increases the overall biological diversity in the forest.

Although these arguments are narrowly and numerically accurate — a clearcut may indeed have more species than the mature stand it replaced, and a forest with scattered patches of clearcuts and interior forest will likely have more species than an unbroken expanse of forest — they share a common fault: they omit the hierarchical priorities of biological diversity discussed above. Forest management that has the effect of increasing the number of species at a local scale without reflecting the relative rarity or commonness of species on a regional or global scale is reducing, not conserving, biological diversity. While clearcutting may increase the number of species in a landscape, it generally benefits common species — "habitat generalists" well adapted to disturbance, and therefore generally common in human-dominated landscapes — at the expense of rarer species — "habitat specialists" that require undisturbed forest and therefore have long been absent from most regions because of human disturbance.

Many wildlife species that depend on mature or old-growth forest, such as red-cockaded woodpeckers in the southeast, and the northern spotted owl in the Pacific Northwest, thus have become endangered. (To be sure, there are a few endangered species — for example, the Kirtland's warbler — that are associated with early-successional habitat and thus could benefit from clearcutting; these species, however, are exceptions to the general rule that habitat specialists and rare species require mature or undisturbed forest.) Certainly, forest management alone did not create this problem — suburban development and agriculture historically have been the major causes. At the current time, however, forest management plays a critical role in determining the continued existence of suitable habitat for plant and animal species in many regions.

APPENDIX: "SMART" QUESTIONS FOR PAPER PURCHASERS

This appendix provides examples of questions that purchasers can use to query and engage in a dialogue with their existing or prospective suppliers. The questions are organized according to the key objectives articulated in the Task Force's forestry recommendations. Information relevant to each set of questions can be found in the rationale section under the corresponding recommendation(s) in Section II above.

The answers to these questions received from suppliers can be used to assess the extent to which a given supplier is concerned about and has acted or is willing to address a given objective; they can also be used to compare different suppliers. These questions are most appropriate for use with the first two categories of purchaser implementation options provided in Section III above.

General Background

Purchasers may wish to gather certain types of background information from their suppliers with regard to their land holdings and management practices in a given region.

Timberland Holdings

- How many acres does the supplier own in the State/Region?
- What fraction of those acres are managed by various means?
  - clearcutting vs. selection methods of harvesting
  - planting vs. natural regeneration

–acres on which fertilizers are applied, and frequency of application
–acres on which pesticides are applied, and frequency of application
• What forest cover types are represented on these lands?

Sources of Pulpwood

• Across the company, or for a specific region or mill, how much of the pulpwood your company/mills consume comes from:
–company-owned lands?
–lands owned by other forest products companies?
–lands owned by non-industrial private companies, institutions or individuals?
–national or state forests or other public lands?
• What fraction of pulpwood coming from non-company-owned lands is purchased:
–under contract with loggers and/or landowners?
–from landowners that are members of your company's landowner assistance program?
–as "gatewood"?
–from audited sources?

Water Quality/Soil Productivity

• Do you routinely monitor the quality of stream water draining watersheds managed by your company? If you own land near coastal areas, do you have a program to monitor the salinity and general quality of estuarine areas?
• Do you employ fertilization on your lands? If so, how do you determine when and how much to fertilize? Do you monitor water quality to determine whether fertilization is affecting it?
• Do you employ pesticides on your lands? If so, how do you determine when and how much to apply? Do you monitor water quality to determine whether pesticide application is affecting it?
• Are efforts made to retain and keep limbs and branches dispersed throughout a harvest area?
• How do you determine the appropriate width of buffer strips? Is there a mechanism to incorporate the results of water quality tests into buffer strip planning?

Adaptive Management/External Input

• What methods do you employ to evaluate the impact of your forestry operations on water quality, wildlife, and plant communities? Can you provide any examples of how your forestry practices have changed over time based on these evaluations?
• What training is made available to your foresters? What level of forestry education is expected of your foresters?
• Are your foresters encouraged and provided with opportunities to interact with local conversation groups, academic institutions or others with expertise and varying perspectives on forestry issues?
• Does your company send representatives to Society of American Foresters meetings? Have you participated (or do you plan on participating) in the most recent Forestry Congress?

Biodiversity and Natural Communities

• Do you employ wildlife biologists? How many do you have on staff? What responsibility and authority do they have with respect to management practices?
• How do you promote diversity on your forest lands? Do you provide any habitat for late-successional species? If so, roughly what proportion of your land?
• Do you have a process for classifying land by habitat type or natural forest cover type?
• Have you taken any steps to enhance habitat for endangered species on your lands?
• Have you identified and classified the location and extent of rare or declining natural communities and ecosystems on your lands? How have you altered (or do you plan to alter) the intensity of your management to accommodate sensitive or valuable natural forest communities or other ecological areas?
• Do you seek a mix of products from your lands, or are a large portion dedicated to fiber production? What fraction of your lands is managed intensively and primarily for wood production? What fraction is managed primarily for non-timber values?
• Have you set aside any lands to be maintained in a natural state? Have you considered land swaps of sensitive lands for lands of relatively lower ecological value such as abandoned agricultural lands?
• If you are still acquiring land, do you seek to purchase abandoned agricultural lands and avoid lands with sensitive eco-

logical sites? Have you sought to concentrate intensive management on abandoned agricultural land?

Harvesting/Regeneration Methods

- Do you employ any alternative harvesting/regeneration methods to clearcutting on your lands? Are you experimenting with or considering alternative harvesting methods? What proportion of your harvest is accomplished through clearcutting in each region? What criteria do you employ in determining when clearcutting is or is not appropriate?
- Where you use artificial regeneration, what is your policy with respect to how long after harvest planting is done? For both natural and artificial regeneration, what measures do you employ to ensure successful regeneration?
- Do you seek to match the characteristics of the harvesting/regeneration method(s) you employ to the disturbance regime characteristic to the region of operation?
- How frequently have you sold land soon after it has been harvested? Were such lands replanted before sale?
- Do you seek to employ certified loggers where certification programs exist?

Purchased Wood/Chips

- What have you done to promote logger and forester certification programs in states in which you operate?
- What fraction of your purchased pulpwood comes from identifiable sources? How much is “gatewood” where the source is not known at the time of purchase? Are you taking steps to identify more of the sources of the pulpwood you purchase, and the forest management practices they use?
- Do you have the ability to audit claims made by your pulpwood suppliers? Do you currently audit any of the sources from which you purchase wood? Do you have plans to?
- What is your policy for purchasing wood with respect to the source’s compliance with Best Management Practices, the AF&PA Sustainable Forestry Initiative and other company policies applicable to your own lands?
- What is your inventory policy for wood and chips at individual mills? Do you maintain sufficient supply to ensure that sound environmental practices need not be circumvented when supplies in a mill’s woodshed are constrained?

Landscape Level Initiatives/Public Lands

- Have you participated in or initiated landscape level management initiatives?
- How is your landowner assistance program structured? What process do you go through to develop management recommendations to these landowners? Do you provide landowners with a full range of environmental and economic information regarding the various management approaches they might choose among, including the potential economic as well as environmental advantages of less intensive management?
- Have you taken a position on any current public land use issues? Have you employed lobbyists or supported industry use of lobbyists to advocate increased harvests on public lands? If so, in which forests?

ENDNOTES

[1] The phrase "forest management" can appropriately be used for any form of deliberate human intervention in forest ecosystem processes, from management for conservation of endangered species habitat to intensive management for pulpwood production. However, for the purposes of this chapter and to avoid redundancy, we will generally use the term "forest management" to refer to management systems designed for the production of fiber, unless stated otherwise. In some cases, fiber is a co-product or by-product of forests managed primarily for solid wood products. These systems will also be considered here.

[2] Many other studies of paper products, including virtually all lifecycle assessments conducted to date, draw the upstream boundary of their analyses *after* the forest: They simply assume a given quantity of trees as an input into the product system being studied. This omission of forest management issues is usually explained by invoking the difficulty of integrating into the analysis the admittedly more qualitative nature of many such impacts; however, a true examination of the full lifecycle of paper requires that they be assessed.

[3] Definitions are adapted from H. Kimmins, *Balancing Act: Environmental Issues in Forestry*, Vancouver: University of British Columbia Press, 1992.

[4] Clearcutting has two forms: "commercial" clearcutting, in which all *merchantable* trees are removed, and "silvicultural" clearcutting, in which all trees on a site are removed. Commercial clearcutting is the more common variation. If the remaining trees on a commercial clearcut are cut anyway to prepare the site for regeneration, the distinction (from an environmental point of view) is minimal; dead trees left standing as snags could provide wildlife habitat, depending on their size.

[5] *Environmental Defense Fund, et al. v. Tidwell*, Civil Action No. 91-467-CIV-5-D, pending in United States District Court for the Eastern District of North Carolina, Raleigh Division.

[6] AF&PA and Wisconsin Paper Council, 1993, *State Forest Practices Throughout The United States*, Washington, D.C.: American Forest & Paper Association.

[7] AF&PA, *Sustainable Forestry Principles and Implementation Guidelines*, Washington, D.C.: American Forest & Paper Association, 1994.

[8] Most but not all pulp and paper companies are AF&PA members.

[9] Society of American Foresters, 1993, *Task force report on sustaining long-term forest health and productivity*, Bethesda, MD: Society of American Foresters.

[10] Forest Stewardship Council, *Principles and Criteria for Natural Forest Management*, Ratification documents dated July 1994, Oaxaca, Mexico. As of this writing, a separate set of principles and criteria was under development to apply specifically to management of plantations.

[11] A *community* is a collection of animal and plant species present in a given location, and is generally viewed as also encompassing the interactions between different species. An *ecosystem* is a complex of animal and plant communities and includes the interaction between such communities.

[12] Best Management Practices (BMPs) are state-level guidelines or requirements for protecting water quality during forestry activities. Of the 38 major timber-producing states, all have some form of BMPs; in 20 of these states, BMP compliance is voluntary, while in the remaining 18 it is mandatory.

[13] Through its research and in discussions with experts in the field, the Task Force found that estimating economic costs and benefits associated with forest management practices, and their impacts and mitigatory measures, was subject to far more uncertainty than were cost estimates associated with either of the other major areas we examined: activities involved in recovering or disposing of used paper, and technologies used in pulp and paper manufacture. White Paper No. 11, contained in the technical supplement (Volume II) of this report, provides a discussion of available information and factors affecting the magnitude of economic costs and benefits. Much of this discussion is by necessity fairly qualitative in nature. White Paper No. 11 also provides a cost structure for pulpwood production, and model simulations of the costs and returns associated with different approaches to management of softwoods in the U.S. South.

[14] Non-industry private forestlands (NIPF) are lands held in private ownership by individuals or institutions other than forest products companies. This ownership class constitutes

nearly 10 million entities, with holdings varying from very small to very large (see White Paper No. 11).

[15] *Suppliers of paper products* may in practice be any of several entities, with relatively more or less direct connection to the management of forestlands from which the fiber was originally acquired. In some cases, purchasers deal directly with the forest products company that owns and manages its own timberland, procures pulpwood from other landowners, and manufactures pulp and paper. Alternatively, the supplier may be a paper manufacturer that does not manage forestland, but purchases pulpwood or pulp from another forest products company. Or the supplier may be an intermediary between the paper manufacturer and the purchaser, such as a paper broker or other merchant. In these recommendations, the term *supplier* will generally be used to refer to the first case of a forest products company. Below we discuss how these recommendations also can be used by purchasers buying from suppliers less directly involved in forest management.

[16] Perennial streams exhibit water flow at all times of the year, while intermittent streams may flow only during storm events or wetter periods.

[17] Most broadly, biodiversity encompasses the diversity of life on the planet. Biodiversity includes *genetic diversity*, the diversity of information encoded in genes within a species; *species diversity*, the diversity and relative abundance of species; and *community/ecosystem diversity*, the diversity of natural communities. The term has been defined as referring to "the variety and variability among living organisms and the ecological complexes in which they occur" (U.S. Congress, Office of Technology Assessment, *Technologies to Maintain Biological Diversity*, OTA-F-330, Washington, DC: U.S. Government Printing Office, 1987). White Paper No. 4 provides a discussion of the importance of conserving biodiversity.

[18] Wildlife corridors are areas of forest managed less intensively or not at all for wood production, placed in the landscape so as to provide connectivity among larger forest preserves or remaining blocks of contiguous forest. Such corridors are believed to allow movement of some wildlife species (e.g., those requiring or preferring forest cover) between larger, non-adjacent areas of habitat, thereby increasing the effective area of habitat. Continuity of such corridors across ownership boundaries may often be necessary for them to serve their intended function.

[19] Hansen, A. J., T. A. Spies, F. J. Swanson, and J. L. Ohmann. 1991. Conserving biodiversity in managed forests: lessons from natural forests. *BioScience 41*(6): 382-392.

[20] Kimmins, 1992, *op. cit.*

[21] Pocosins take their name from an Algonquin Indian word meaning "swamp-on-a-hill." They are freshwater evergreen shrub or forested bogs restricted primarily to the coastal plain of the Carolinas, generally found on flat, slightly elevated and very poorly drained areas between rivers.

[22] Linda Pearsall, Head of Natural Heritage Program, State of North Carolina Department of Environment, Health and Natural Resources, letter dated August 12, 1993 to Mr. Derb Carter, Southern Environmental Law Center, attaching the listing report; and computer printout of Natural Heritage Program community type and status listings, August 7, 1995.

[23] Clearcutting as a generic term can encompass several variant methods that share the characteristic of removing most or all of the trees in a given area: "true" clearcutting, in which essentially all the trees are removed from the site; stripcutting, in which trees are removed in strips; shelterwood harvests, in which a sparse overstory is retained to shelter the regenerating stand, and is removed in a subsequent harvest; and seed-tree harvests, in which a few trees are retained on the site to provide a natural seed source for the next stand. The magnitude of impacts under the conditions specified in this measure will vary, with methods that leave more trees generally producing less pronounced impacts.

[24] Selection methods refer to harvesting techniques of a more limited but continuous nature, involving removal of only a fraction of the trees in a given area at a given time. Methods include single-tree selection and group selection (removal of groups of trees at one time). The magnitude of impacts discussed under this measure will be a function of both the fraction of trees removed and the frequency of stand entries.

[25] However, this soil disturbance is generally of less magnitude and extent than the disturbance from a clearcut; moreover, the frequency of stand entry in highly intensive, even-aged plantation management may approach that of a selectively harvested stand.

[26] For the purposes of this paper, the terms "Best Management Practices" and "BMPs" are used to refer to *all* forestry practices contained in state-level forest management guidelines or legislation. The terms as used here thus encompass the practices required by the mandatory forest practice acts in some states as well as the voluntary or quasi-regulatory BMP programs in other states.

[27] Regional boundaries follow the Forest Service's main definition. The South includes Virginia, North and South Carolina, Georgia, Florida, Tennessee, Alabama, Mississippi, Louisiana, Arkansas, Texas and Oklahoma. The North extends as far west as the Great Plains (including North and South Dakota, Kansas and Nebraska). The West comprises the remaining 13 states.

[28] Noss, R. F. 1989. Longleaf pine and wiregrass: Keystone components of an endangered ecosystem. *Natural Areas J.* 9(4): 211-213.

[29] The Forest Service's projections reported in this chapter are derived from application and linkage of its forest sector models: NAPAP, the North American Pulp and Paper model, a sectoral model of demand, supply and technology for the pulp and paper sector in the U.S. and Canada; ATLAS, the Aggregate Timberland Assessment System, a forest inventory change model for private timberland in the U.S.; and TAMM, the Timberland Assessment Market Model, an economic model of the U.S. forest sector. Models and assumptions are described in detail in Ince, P.J. *et al.* (1993) *The North American Pulp and Paper* (NAPAP) Model, USDA Forest Service, U.S. Forest Products Laboratory: Madison, WI; Adams, D.M. and Haynes, R.W. (1980) "The 1980 Timber Assessment Market Model: Structure, Projections and Policy Implications," *Forest Science* 26(3): Monograph 22, 64 pp.; and Haynes, R.W. and Adams, D.M. (1985) *Simulations of the Effects of Alternative Assumptions on Demand-Supply Determinants of the Timber Situation in the United States*, Washington, DC: U.S. Department of Agriculture, Forest Service, Forest Resources Economics Research, 113 pp.

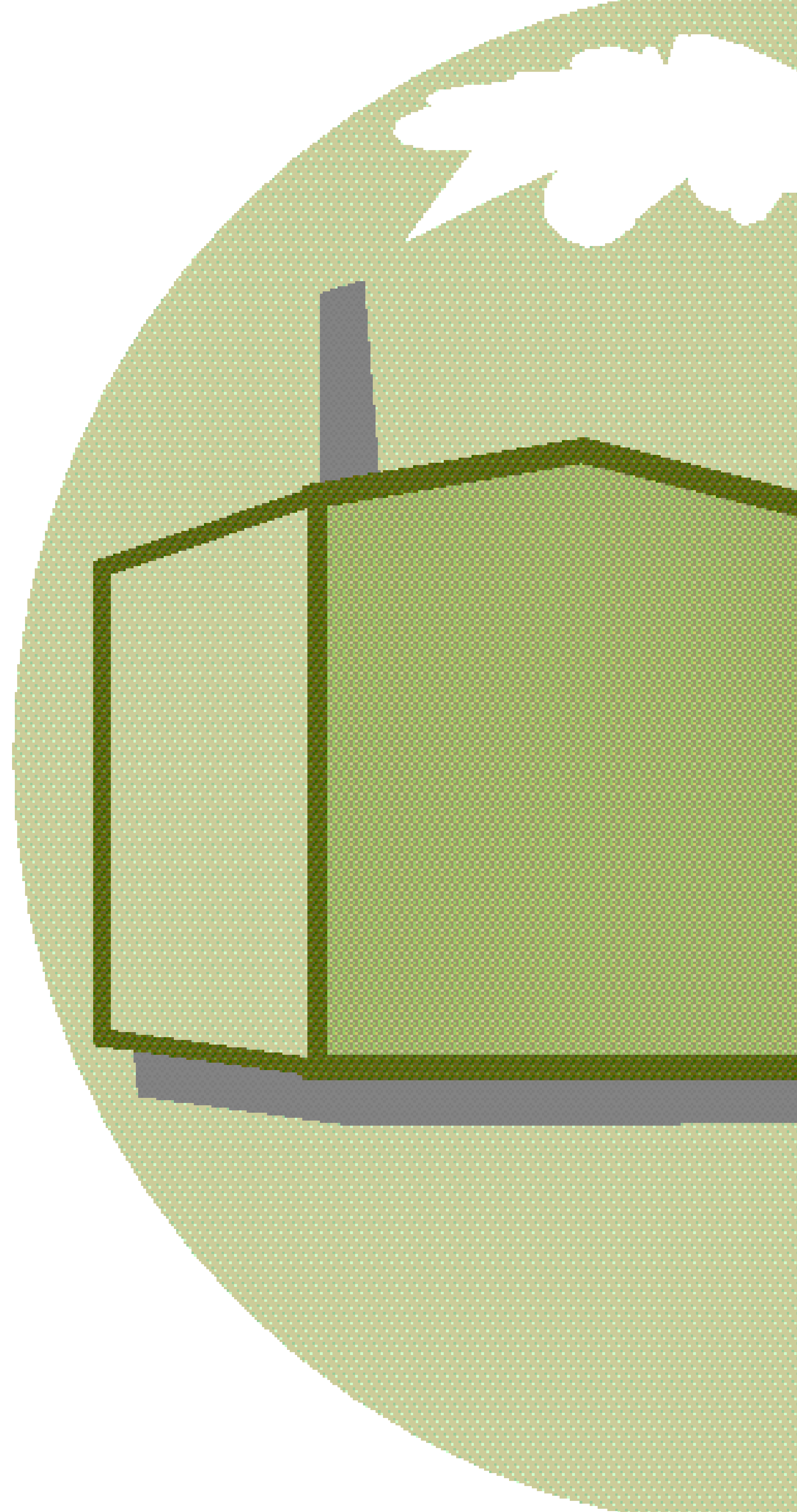
[30] Resource Information Systems, Inc., *Timber Review*, December 1994: 10(4); and Resource Information Systems, Inc., *Pulp and Paper Review*, July 1995: 19(2).

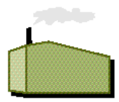
[31] These models assume as a base case that the recovered paper utilization rate reaches 37.5% by the year 2000 and 45.4% in 2040; a "waste reduction" case assumes a 45% utilization rate in 2000, rising to 60% by 2020 and remaining at that level through 2040 (Ince, P.J. *Recycling and Long-Range Timber Outlook*, Gen. Tech. Rept. RM-242 (Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, February 1994)). For comparison, the forest products industry has set a goal for 40% utilization in 2000, and utilization had reached 33.1% in 1994 (American Forest & Paper Association (1995) *1995 Annual Statistical Summary: Recovered Paper Utilization* (Washington, D.C.: AF&PA), p. 81; Franklin Associates, (1993) *The Outlook for Paper Recovery to the Year 2000*, Executive Summary, prepared for the American Forest & Paper Association, Washington, DC, November 1993, p. 7; American Forest & Paper Association, press release dated December 8, 1993, "U.S. Paper Industry Sets Goal to Recover Half of All Paper Used," Washington, DC.).

[32] Data provided to the Paper Task Force by Richard Haynes, Pacific Northwest Research Station, USDA Forest Service, Portland, OR, by letter dated June 16, 1995; the data supplement those provided in Haynes, R.W. *et al.* (1995) *The 1993 RPA Timber Assessment Update*, USDA Forest Service, General Techincal Report RM-259 (Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, March 1995).

5

PULP AND PAPER MANUFACTURING





PULP AND PAPER MANUFACTURING

This chapter and the Paper Task Force recommendations on pulp and paper manufacturing are intended to:

- Enhance the awareness and knowledge of purchasers and users of paper, by providing clear information on several pulp and paper manufacturing processes and their environmental performance.
- Formulate a number of simple actions that purchasers can take to purchase paper made with environmentally preferable manufacturing processes.
- Provide specific guidance that purchasers can use to incorporate an assessment of the environmental performance of pulp and paper manufacturing processes as an explicit purchasing criterion, along with more traditional criteria such as availability, cost and product performance.

I. INTRODUCTION

This chapter presents the Paper Task Force's recommendations and implementation options for buying paper products made with environmentally preferable manufacturing processes. It also provides a summary of the supporting rationale for the recommendations and an overview of pulp and paper manufacturing processes.

How Is Pulp and Paper Manufacturing Relevant to Purchasers?

Pulp and paper manufacturing accounts for the vast majority of the environmental impacts of the paper lifecycle. The manufacturing process that transforms wood from trees into thin, uniform paper products requires the intensive use of wood, energy and chemicals. This process also consumes thousands of gallons of a finite resource, clean water, to make each ton of paper. Pollution literally represents a waste of these resources, in the form of air emissions, waterborne wastes (effluent), solid waste and waste heat. Among primary manufacturing industries, for example, paper manufacturing is the fourth-largest user of energy and the largest generator of wastes, measured by weight.[1]

The paper industry and the nation's environmental laws have done much to reduce the environmental impacts of pulp and paper manufacturing over the last 25 years. In this resource-intensive industry, however, environmental issues will always be an intrinsic part of manufacturing, especially since awareness of these impacts has increased among communities near mills and customers alike. Fortunately, there are many ways to reduce these impacts.

The concept of *pollution prevention* forms the foundation of the Paper Task Force's recommendations on pulp and paper manufacturing. Pollution-prevention approaches use resources more efficiently and thus reduce pollution at the source as opposed to "end-of-the-pipe" *pollution-control* approaches.

As this chapter will show, it is in paper users' interest to send clear, long-term signals of their preference for paper products made using pollution-prevention approaches. Over the last two years paper manufacturers have built up cash resources as a result of recent high paper prices and are preparing for their next round of investments. The time is right for purchasers to use the market to send a signal about their long-term environmental preferences.

Overview of the Chapter

The presentation in this chapter builds in sequence through six major sections:

- An *overview of the pulp and paper manufacturing process*. For readers not familiar with pulp and paper manufacturing, this section defines the basic concepts and technical terms that are used in the recommendations. The section begins by describing the raw materials and other inputs used in pulp and paper manufacturing, such as wood, water, chemicals and energy. The section next explains how these inputs are transformed into products in the pulp and paper manufacturing process. Since manufacturing is not 100% efficient, wastes are also generated in manufacturing. Approaches to reducing or managing these wastes through pollution prevention and pollution control are described in the last parts of this section.

  All major virgin and recycled-fiber pulping and paper manufacturing technologies used in North America are described in this section. Bleached kraft pulp, which is used to make white paper products, is described in somewhat more detail than other technologies. Bleached kraft pulp makes up approximately 46% of virgin pulp production in the United States. It is used in the highest-value paper products and raises some unique environmental issues as compared to other pulp manufacturing technologies.
- The *environmental and economic context for the recommendations*. This section provides the environmental and economic rationale for using pollution-prevention approaches in manufacturing. We also explain how preferences expressed by paper users influence the strategy and timing of paper suppliers' investments in manufacturing.
- The *recommendations*, with additional environmental and economic rationale and discussion of the availability of different types of paper products. The eight recommendations fall into two categories:
  - Minimum-impact mills – the goal of which is to minimize natural resource consumption (wood, water, energy) and minimize the quantity and maximize the quality of releases to air, water and land through:
    a. a vision and commitment to the minimum-impact mill
    b. an environmental management system
    c. manufacturing technologies
  - Product reformulation by changing the types of pulps used in paper products
- *Implementation options*, which provide paper purchasers with several techniques for applying the descriptive information in the recommendations to their purchasing decisions.
- *Answers to frequently asked questions* about environmental and economic issues in pulp and paper manufacturing.
- *Appendices* that contain additional data and analysis in support of the Task Force's recommendations and presentations in the chapter.

II. OVERVIEW OF PULP AND PAPER MANUFACTURING PROCESSES

While purchasers are familiar with the specifications and performance requirements of the papers they buy, they are often less familiar with how paper is made. This overview provides a brief description of the papermaking process and defines key terms that are used in the recommendations.

The papermaking process consists of three basic steps that transform cellulose fibers in wood, recovered waste paper and other plants into paper:

- First, the raw material is pulped to produce usable fibers
- Second, in the case of many white paper products, the pulp is bleached or brightened
- Third, the pulp is made into paper

The basic steps of the pulp and papermaking process are illustrated in **Figure 1**.

Paper has always been made from cellulose, an abundant natural fiber obtained from plants. In early papermaking processes, the plant containing the fiber was cut into small pieces and mashed in water to isolate the fibers. The resulting slurry was then poured into a wire mesh mold; excess water was pressed out and the sheet of paper was dried. Although these fundamental steps remain at the essence of papermaking operations, the scale and complexity of pulping and papermaking processes have changed dramatically in the last century. The vast majority of paper producers now use wood as the source of cellulose fiber, which requires the additional application of energy and chemicals in the pulping stage to obtain usable fiber. Some paper products also use coatings, fillers and other additives to meet specific performance requirements, such as a smooth printing surface.

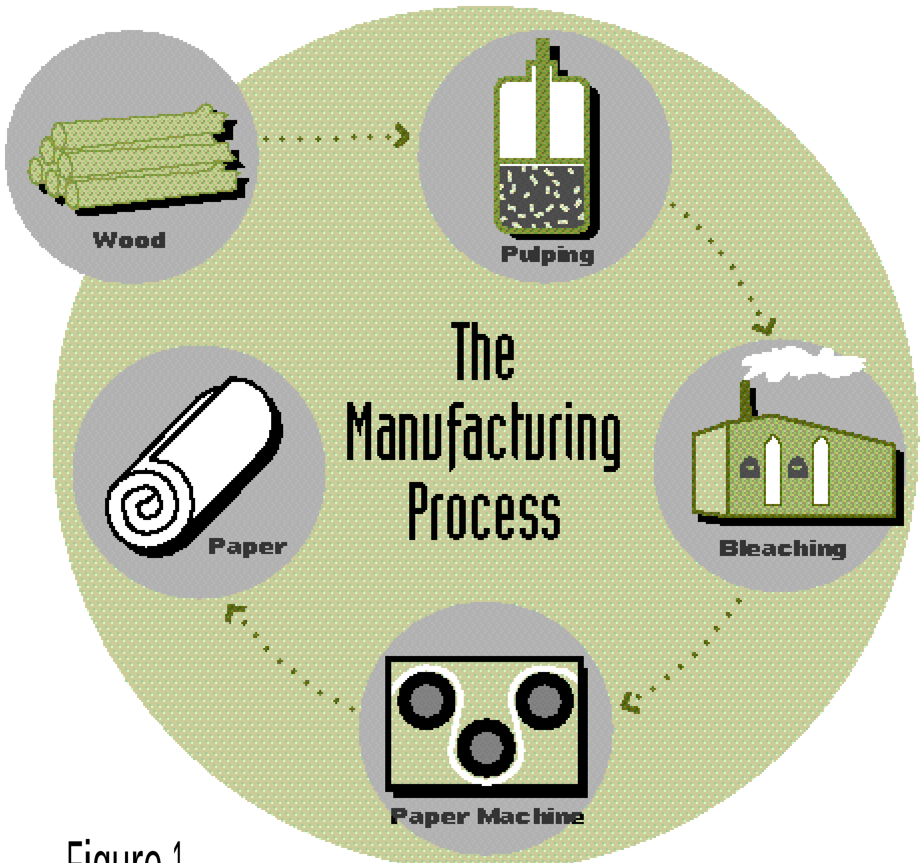


Figure 1

Raw Materials and Other Inputs

The papermaking process requires four major inputs: a source of fiber, chemicals, energy and water.

1. Fiber Sources

Wood is a composite material consisting of flexible cellulose fibers bonded together and made rigid by a complex organic "glue" called lignin. Slightly less than half of the wood in the tree is actually made up of the cellulose fibers that are desired for making paper. The remainder of the tree is lignin, wood sugars and other compounds. Separating the wood fibers from the lignin is the task of chemical pulping processes, described below.

Softwood trees contain more lignin than hardwoods.[2] Softwood fibers also are longer and coarser than hardwood fibers. Softwood fibers give paper its strength to withstand stretching and tearing, while hardwood fibers provide a smooth surface.[3] The greater amount of lignin present in softwoods means that more chemicals and energy must be applied to separate lignin from fiber in the kraft pulping process, as described below.

A wide array of non-wood plants also serve as a raw material for paper, especially in countries that lack forests. Non-wood fibers can be grouped into annual crops, such as flax, kenaf and hemp, and agricultural residues, such as rye, and wheat straw, and fiber from sugar cane (bagasse). Annual crops are often grown specifically for paper production, while agricultural residues are by-products of crops grown for other uses.

Recovered fiber comes from used paper items obtained from recycling collection programs (see Chapter 3). Paper-recycling professionals recognize numerous grades and sub-grades of recovered paper, such as old newspapers, old corrugated containers and sorted office paper.[4] Many of the properties of specific grades of recovered paper that make them desirable or undesirable in specific recycled paper products are determined by the process used in manufacturing the virgin pulp and paper when it was first made. For example, the strong brown fibers of a corrugated box are well suited to be used again in the same product, but are very unlikely to be used in newspapers or magazines.

The properties of recovered paper used in recycling-based manufacturing processes are also determined by the presence of contaminants added to the paper or picked up in the separation of recovered paper from solid waste or in the recycling collection process. These different contaminants can include, for example, different types of ink, wax and clay coatings, non-fiber filler materials used in the paper, adhesives, tape, staples and pieces of plastic, metal and dirt.

2. Chemicals

Manufacturing pulp and paper from wood is a chemical-intensive process. Kraft and sulfite pulping, described in more detail below, cook wood chips in a chemical solution to dissolve the lignin that binds the fibers together.[5] The cleaning and processing of recovered paper fiber uses a solution of caustic soda[6] to separate the fibers, as do some mechanical pulping processes. Mills also use combinations of chlorine- and oxygen-based chemicals to bleach or brighten the pulp. Numerous coatings, fillers and other additives are added to the pulp during the papermaking process to facilitate manufacturing and meet the functional requirements of different types of paper.[7]

3. Energy

Pulp and paper mills use a combination of electricity and steam throughout the papermaking process. Mills consume about 31 million Btu's of energy to produce a ton of paper or paperboard. To put this energy consumption in perspective, occupants of an average suburban U.S. home consume this much energy in two months.[8]

The source of this energy depends on the type of pulping process. Chemical pulping processes have special recovery systems that allow them to convert wood waste from the pulping process into electricity and steam. Mechanical pulping processes (described below) that convert more of the wood into pulp have less wood waste to burn, and therefore must purchase electricity or fossil fuels to meet their energy needs.

The purchased energy used by pulp and paper mills can come from a variety of sources, such as hydroelectric power, natural gas, coal or oil. The mill itself may have systems for generating energy from all of these sources, or may purch electricity from utilities.

4. Water

Water is the basic process medium of pulp and paper manufacturing; it carries the fibers through each manufacturing step and chemical treatment, and separates spent pulping chemicals and the complex mixture of organic residues from the pulp. Papermaking processes use significant amounts of water. Average water use ranges from about 11,600 to 22,000 gallons per ton of product depending on the processes used and the products made at the mill.[9]

Table 1

United States Capacity to Produce Wood Pulp
(Excluding Construction Grades)

TYPEOFPULP	THOUSANDS OF SHORT TONS	PERCENTAGE OF TOTAL PRODUCTION
Kraft pulp total	54,150	79%
bleached and semi-bleached	31,287	46%
hardwood	16,526	24%
softwood	14,761	22%
unbleached	22,863	34%
Papergrade sulfite	1,423	2%
Semichemical	4,408	6%
Mechanical pulp total	7,168	11%
stone and refiner groundwood	3,281	5%
thermomechanical	3,887	6%
Dissolving and special alpha	1,227	2%
Total, all grades	68,126	

Source: Preliminary capacity estimates for 1995. American Forest & Paper Association, 1995 Statistics, Paperboard and Wood Pulp, Sept., 1995, p. 35.

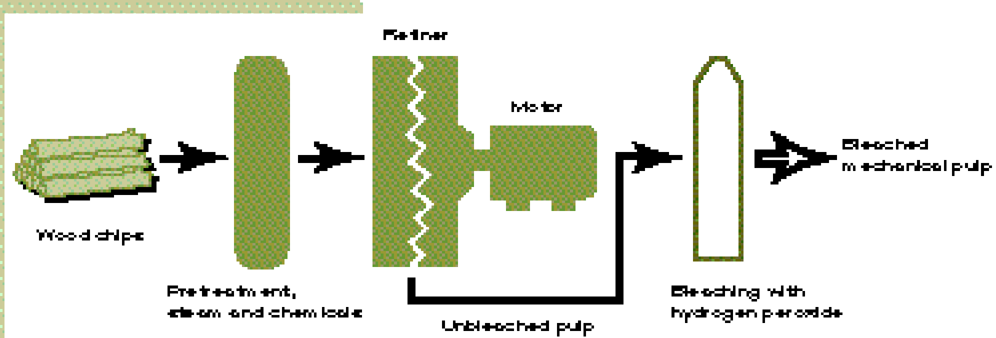
Pulp and Paper Manufacturing

Pulp manufacturing consists of one or two basic steps, depending on whether the final product requires whit pulp. There are two general classes of processes. In *mech ical* pulping, mechanical energy is used to physically sep the fibers from the wood. In *chemical* pulping, a combin chemicals, heat and pressure breaks down the lignin od so that it can be washed away from the cellulose ibers. For white paper products, the pulp undergoes additional chemical treatment, colloquially known as bleaching, to remove additional lignin and/or brighten the pulp. The processing of recovered (used) paper first separates the paper fibers from each other and then removes contaminants floating in the pulp slurry.

Table 1 illustrates the estimated production capacity of different types of virgin pulp manufacturing processes in the United

Figure 2

Production of Mechanical Pulp



States in 1995. Chemical pulp produced by the kraft process accounts for 79% of total production capacity, and bleached and semi-bleached pulp accounts for 46% of total production capacity.

1. Mechanical Pulp Production

'here are several types of mechanical pulping processes. *stone groundwood* processes, wood is pressed against a stone in the presence of water and the fibers are separom the wood, hence the term "groundwood" pulp.

Pressurized groundwood processes are similar, but operate at higher pressure to produce a stronger pulp. In *thermomechanical pulping (TMP)*, steam is applied to wood chips, which are then pressed between two large, rotating disks, known as *refiners*. As shown in Figure 2, these steps physically separate the wood into fibers. These mechanical pulping methods typically convert 90-95% of the wood used in the process into pulp. (Figure 2 and other figures describing pulp and paper manufacturing processes are simplified in order to convey major points. More realistic and complex diagrams can be found in technical reference books.[10])

The *chemithermomechanical pulping (CTMP)* process exposes wood chips to steam and chemicals before separating the fibers. The resulting pulps are stronger than other mechanical pulps and require less electrical energy to produce. CTMP can be bleached to produce *bleached chemithermomechanical pulps (BCTMP)* with yields of 87-90%.[11]

Mechanical pulps are also known as *high-yield* pulps because they convert almost all of the wood used in the process to paper. Therefore, as compared to chemical pulping processes, fewer trees are required to produce a ton of pulp. Because mechanical processes use most of the tree, the pulps contain lignin, which may cause the paper to yellow when exposed to sunlight. This is what happens when a newspaper is left outdoors for a few days. The naturally low lignin content of certain hardwood species allows the production of high-brightness mechanical pulps, such as hardwood BCTMP, and reduces this change in brightness and color.[12]

The short, stiff fibers produced in mechanical pulping processes provide a smooth printing surface and greater opacity, as compared to chemical pulps. They also are comparatively inexpensive to produce, but have about half the strength of kraft pulps. Mechanical pulps are therefore generally unsuitable for applications where strength is important, which typically means packaging. Mechanical pulps are used in newsprint, magazines and other applications that require opacity at low basis weight and are sometimes blended with softwood kraft pulp in these uses.

2. Chemical Pulp Production

Two chemical pulping processes, kraft and sulfite pulping, isolate cellulose fibers by dissolving the lignin in the wood. Almost all the chemical pulp in the United States is produced by the kraft process.

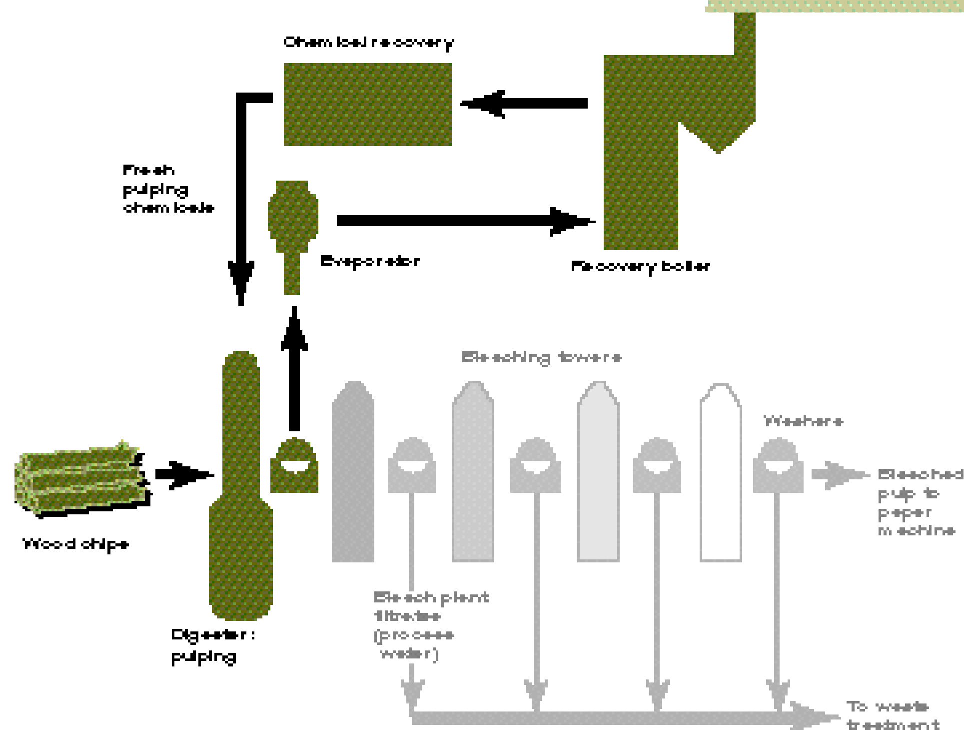
In the kraft process, as illustrated in Figure 3, wood chips are cooked with chemicals and heat in a large vessel called a *digester*. Once the lignin has been dissolved and the wood chips have been converted to pulp, the pulp is washed to separate it from the "black liquor," a mix of spent pulping chemicals, degraded lignin by-products and extractive compounds. The unbleached kraft pulp at this point is dark brown. Its long, strong fibers are used in grocery bags and corrugated shipping containers. About 95% of the lignin is removed from the wood fibers in the pulping process. To make white paper, the unbleached kraft pulp must undergo additional processing to remove the remaining lignin and brighten the pulp.

The chemical recovery process is an integral part of the kraft pulping process. In this process, water is removed from the black liquor in a series of evaporators. The concentrated black liquor is then sent to a very large, special furnace called the *recovery boiler*. The organic wood residue in the black liquor has a significant energy content and is burned near the top of the recovery boiler to produce steam for mill operations. At the base of the recovery boiler, the used pulping chemicals accumulate in a molten, lava-like smelt. After further chemical treatment and processing at the mill, these chemicals are reused in the pulping process. Through this internal recycling process, most chemical recovery systems recover about 99% of the pulping chemicals.[13] Moreover, modern kraft pulp mills are generally self-sufficient in their use of energy due to their ability to burn wood by-products. The water from the evaporators is usually clean enough to be used in other parts of the mill.

The sulfite process, an older process, accounts for less than 2% of U.S. pulp production. Sulfite mills use different chemicals to remove the lignin from the wood fibers. First, sulfurous acid (H_2SO_3) chemically modifies the lignin;[14] then exposure to alkali[15] makes the lignin soluble in water. The sulfite process produces different types of lignin by-products than does the

Figure 3

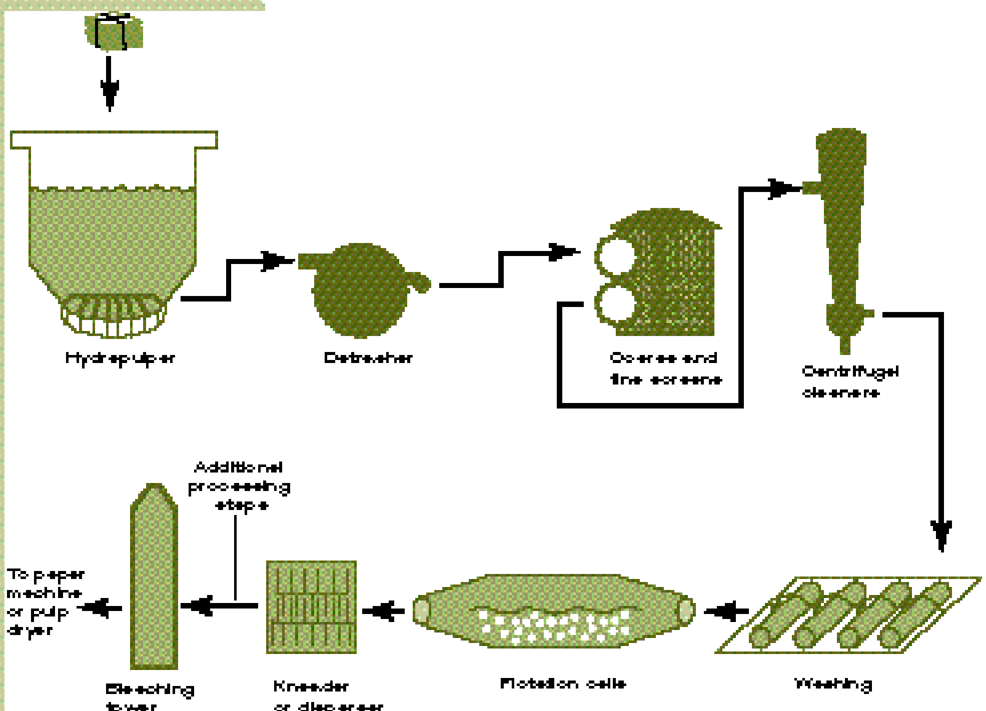
Bleached Kraft Pulp Production: Pulping



kraft process. Some sulfite mills sell these lignin by-products rather than recover the chemicals. The sulfite process produces a weaker pulp than the kraft process and can use wood from fewer tree species.

Figure 4

Recovered Fiber Deinking Process



3. Recovered Fiber Pulping and Cleaning

Figure 4 provides a simplified diagram of a recovered paper cleaning and processing system. The first step in all conventional recycling-based pulping operations is to separate the fibers in the paper sheet from each other. This is done in a *hydrapulper*, a large vessel filled with recovered paper and water with a rotor at the bottom, like a giant blender. Ink, dirt, plastic and other contaminants are also detached from the paper fibers in this step. Subsequently the mill applies a variety of mechanical processing steps to separate the fibers from the contaminants in the pulp slurry. Achieving a near-complete removal of contaminants is most critical for *deinking* systems used to make pulp for printing and writing paper, tissue and newsprint.[16]

Mechanical separation equipment includes coarse and fine screens, centrifugal cleaners, and dispersion or kneading units that break apart ink particles. Deinking processes use special systems aided by soaps or surfactants to wash or float ink and other particles away from the fiber. A minority of deinking systems also use chemicals that cause ink particles from photocopy machines and laser-jet computer printers to agglomerate into clumps so they can be screened out.

4. Bleaching

a. Mechanical Pulps

For most types of paper produced by the groundwood and TMP processes, non-chlorine-based chemicals, such as hydrogen peroxide, brighten the pulp to produce pulps of 60-70 GE brightness. Hardwood BCTMP pulps can achieve levels of 85-87 GE brightness. 90 GE brightness is considered a high-brightness pulp. As a point of comparison, newsprint is 60-65 GE brightness, and standard photocopy paper grades are 83-86 brightness. Pulp is produced at high brightness levels, because 1-2 points of brightness are lost in the papermaking process. See the Explanation of Key Terms and Abbreviations for an explanation of how brightness is measured. For further discussion, see the Answers to Frequently Asked Questions at the end of this chapter.

b. Kraft Pulps
In the bleaching process for chemical pulps, more selective chemicals remove the remaining lignin in the pulp and brighten the brown, unbleached pulp to a white pulp. As shown in Figure 5, mills generally employ three to five bleaching stages and wash the pulp between each stage to dissolve the degraded lignin and separate it from the fibers. The first two bleaching stages generally remove the remaining lignin while the final stages brighten the pulp.

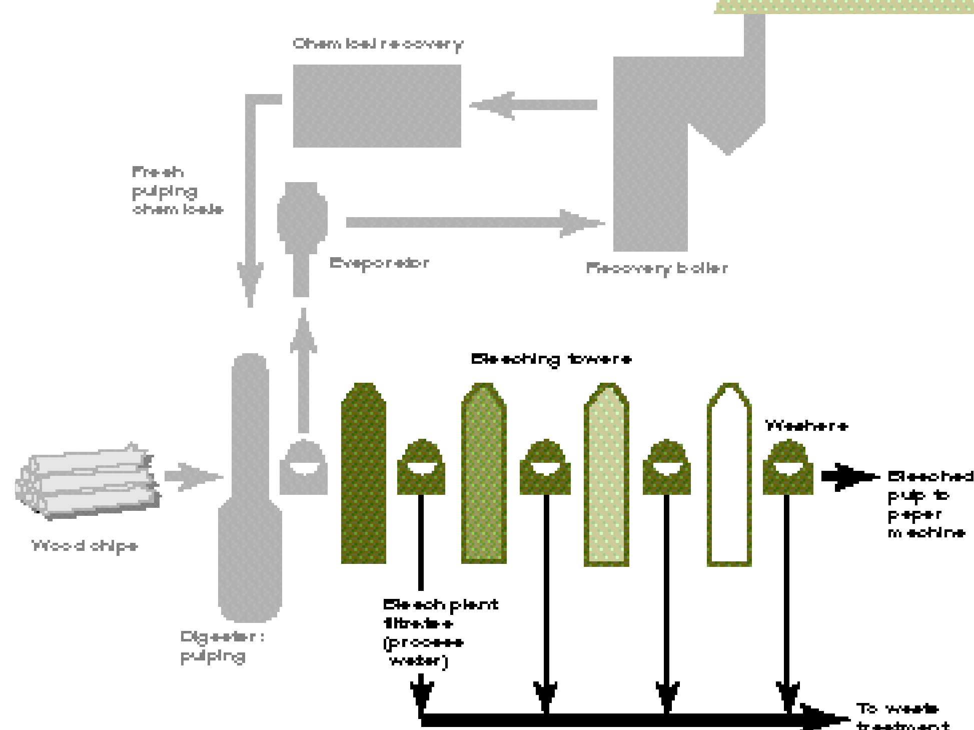
Mills have traditionally used elemental chlorine with a small amount of chlorine dioxide, which are strong oxidants, to break down the remaining lignin in the unbleached kraft pulp. In response to the discovery of dioxin downstream from pulp mills in 1985, most bleached pulp mills have reduced, and some have eliminated, elemental chlorine from the bleaching process, usually by substituting chlorine dioxide. Bleaching processes that substitute chlorine dioxide for all of the elemental chlorine in the bleaching process are called *elemental chlorine-free (ECF) processes.*

Lignin is a complex organic compound that must be chemically broken down to separate the fibers. Degrading lignin using chlorine and chlorine dioxide creates hundreds of different types of chlorinated and non-chlorinated organic compounds. In the second stage of the bleaching sequence, following the application of chlorine dioxide, the pulp is exposed to a solution of caustic (sodium hydroxide) to dissolve the degraded lignin in water so that it can be washed out of the pulp. The degraded lignin by-products are a major source of organic waste in the effluent from the pulp mill. These first two bleaching stages account for 85-90% of the color and organic material in the effluent from the bleach plant.[17] In the final bleaching stages, chlorine dioxide or hydrogen peroxide are currently used to brighten the pulp.

c. Sulfite Pulps
The unbleached pulp manufactured in the sulfite process is a creamy beige color, instead of the dark brown of unbleached kraft pulp. This means that sulfite pulps can be bleached to a high brightness without the use of chlorine compounds. The handful of sulfite paper mills operating in the United States have traditionally used elemental chlorine and sodium hypochlorite as bleaching agents. These mills are now shifting to *totally chlorine-free (TCF)* bleaching processes that use hydro-

Figure 5

Bleached Kraft Pulp Production: Bleaching



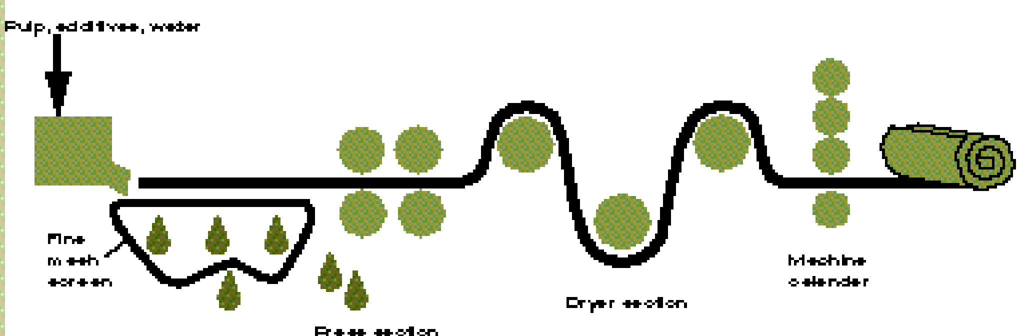
n peroxide in order to comply with regulations and educe their generation of chloroform, dioxins and other chlorinated organic compounds.

d. Recovered Fiber Pulps

At least 63% of recovered fiber pulps consumed by paper mills in the United States are used in applications that do not require them to be brightened, such as containerboard or 100% recycled paperboard packaging.[18] Deinked pulps used in newsprint, tissue and printing and writing papers require less brightening than virgin

Figure 6

Paper Machine



bleached kraft pulps because they have already been processed (bleached) once.

In the past, some deinking mills have used elemental chlorine, sodium hypochlorite or chlorine dioxide to strip dyes from used colored paper and to brighten the pulp. The current state of the art in deinking is TCF pulp brightening,[19] which is used in the large najority of deinking facilities now operating in the United ıtes.[20] Like mechanical pulp mills, deinking mills that ess old newspapers and magazines brighten these pulps ydrogen peroxide and other non-chlorine compounds.

5. Papermaking

Figure 6 illustrates the steps in the papermaking process. As it enters the papermaking process, the pulp is diluted to about 99% water and 1% fiber. On the paper machine, the pulp is first sprayed onto a fast-moving, continuous mesh screen. A fiber mat is formed as gravity and vacuum pumps drain the water away from the pulp. The fiber mat passes through a series of rollers in the press section where more water is squeezed out, followed by a series of steam-heated cylinders that evaporate most of the remaining water. As water is removed, chemical bonds form between the fibers, creating the paper sheet. Depending on the grade of paper being made, such machines can produce a roll of paper up to 30 feet wide and as fast as 50 miles per hour. There are many variations on this basic type of papermaking technology.

Releases to the Environment

No manufacturing process converts all of its inputs into final products. There is always some waste. The waste from pulp and paper manufacturing includes releases to air, land and water, as well as waste heat. In 1991, the pulp and paper industry discharged 2.25 billion tons of waste to the environment.[21] This waste included about 2.5 million tons of air emissions from energy-related and process sources[22] and about 13.5 million tons of solid waste[23], leaving 2.23 billion tons of wastewater. Thus over 99% of the waste, measured by weight, was wastewater.

A number of measures provide information about the consumption of natural resources and releases to the environment. Definitions of some of the indicators discussed throughout the chapter follow:

Measures of Natural Resource Consumption

- Pulp yield measures the amount of wood consumed to produce a ton of pulp. Pulping processes with lower yields consume more wood to produce a ton of pulp. The unit of measure is a percentage.
- Fresh water use measures the amount of fresh water consumed during the production of a ton of final product. The unit of measure is gallons per ton of final product.

- **Total energy consumption** measures the energy demand of the process equipment to produce a ton of pulp or paper. Installation of energy-saving technologies and identifying process modifications that may save energy will reduce the total energy consumption. The unit of measure is millions of Btu's per ton of final product.
- **Purchased energy consumption** measures the amount of purchased electricity and fuel that mills use to run the equipment and to generate process steam. Cogeneration and more efficient combustion of lignin and other wood waste decreases the purchased energy consumption of the mill. The unit of measure is millions of Btu's per ton of final product.

Measures of Releases to Air

- **Carbon dioxide (CO_2)** results from the complete combustion of the carbon in organic materials. Combustion of biomass (wood waste) and fossil fuels generates carbon dioxide. Carbon dioxide is a greenhouse gas that is associated with global climate change.[24] The unit of measure is pounds per ton of final product.
- **Chloroform,** a hazardous air pollutant, is classified as a probable human carcinogen. The unit of measure is pounds per air-dried ton of final product.
- **Hazardous air pollutants (HAPs)** are a group of 189 substances identified in the 1990 Clean Air Act Amendments because of their toxicity. The unit of measure is pounds per ton of final product.
- **Particulates** are small particles that are dispersed into the atmosphere during combustion. The ash content of a fuel determines the particulate generation upon combustion. Kraft recovery boilers generate particulate emissions of sodium sulfate and sodium carbonate. The unit of measure is pounds per ton of final product.
- **Sulfur dioxide and nitrogen oxides** emissions result from the burning of fuel in boilers and serve as a measure of the energy efficiency of the mill and of the control devices that mills have installed to reduce these emissions. The unit of measure is pounds per ton of final product.
- **Total reduced sulfur compounds (TRS)** cause the unique kraft mill odor. Reducing the release of these compounds can improve the quality of life in the local community. The unit of measure is pounds per ton of final product.
- **Volatile organic compounds (VOCs)** are a broad class of organic gases, such a vapors from solvent and gasoline. The control of VOC emissions is important because these compounds react with nitrogen oxides (NO_X) to form ozone in the atmosphere, the major component of photochemical smog.[25] The unit of measure is pounds per ton of final product.

Measures of Releases to Water

- **Adsorbable organic halogens (AOX)** measures the quantity of chlorinated organic compounds in mill effluent and is an indirect indicator of the quantity of elemental chlorine present in the bleach plant and the amount of lignin in the unbleached pulp before it enters the bleach plant. Because research to date has not linked AOX with specific environmental impacts, the Paper Task Force recommends that AOX be used as a measure of a mill's process. The unit of measure is kilograms per metric ton of air-dried pulp.
- **Biochemical oxygen demand (BOD)** measures the amount of oxygen that microorganisms consume to degrade the organic material in the effluent. Discharging effluent with high levels of BOD can result in the reduction of dissolved oxygen in mills' receiving waters, which may adversely affect fish and other organisms. The unit of measure is usually kilograms per metric ton of final product.
- **Bleach plant effluent flow** measures the quantity of bleach plant filtrates that the mill cannot recirculate to the chemical recovery system. This indicator provides direct information about a mill's position on the minimum-impact mill technology pathway. For example, mills that recirculate the filtrates from the first bleaching and extraction stages have about 70-90% less bleach plant effluent than do mills with traditional bleaching processes. The unit of measure is gallons per ton of air-dried pulp.
- **Chemical oxygen demand (COD)** measures the amount of oxidizable organic matter in the mills' effluent. It provides a measure of the performance of the spill prevention and control programs as well as the quantity of organic waste discharged from the bleach plant. The unit of measure is

kilograms per metric ton of air-dried pulp.

- Color measures the amount of light that can penetrate the effluent. In certain situations, color can adversely affect the growth of algae and plants in mills' receiving waters. It also provides information about the quantity of degraded lignin by-products in the effluent because these substances tend to be highly colored. Along with odor, the dark effluent is one of the obvious attributes of kraft pulp mills. The unit of measure is either color units per metric ton of final product or kilograms per metric ton of final product.
- Dioxins are a group of persistent, toxic substances, including furans, that are produced in trace amounts when unbleached pulp is exposed to elemental chlorine. The unit of measure for bleach plant filtrates is picograms of dioxin per liter of water (parts per quadrillion).
- Effluent flow measures the amount of water that is treated and discharged to a mill's receiving waters. It is an indirect measure of fresh water consumption. The unit of measure is gallons per ton of final product.
- Total suspended solids (TSS) measure the amount of bark, wood fiber, dirt, grit and other debris that may be present in mill effluent. TSS can cause a range of effects from increasing the water turbidity to physically covering and smothering stationery or immobile bottom-dwelling plants and animals in freshwater, estuarine or marine ecosystems. The unit of measure is kilograms per air-dried metric ton of final product.

1. Releases to Air

Pulp and paper mills generate air emissions from energy-related and process sources. Energy-related air emissions result from the combustion of wood and fossil fuels and include sulfur dioxide, nitrogen oxides, particulates and carbon dioxide. The quantity of these emissions depends on the mix of fuels used to generate the energy at the mill. Based on the fuel mix of the U.S. national grid, mills that purchase electricity will have relatively high emissions of sulfur dioxide, nitrogen oxides, particulates and carbon dioxide from fossil fuels. The fuel mix for individual mills, however, varies by region. Mills in the Pacific Northwest, for example, might use hydropower and thus have very low energy-related air emissions.[26] Mills using electricity generated from natural gas have lower energy-related emissions than those using electricity generated from oil or coal.

Mills also release air pollutants from process sources, including the pulping, bleaching and, at chemical pulp mills, chemical recovery systems. Hazardous air pollutants (HAPs) and volatile organic compounds (VOCs) account for most of the air emissions from process sources. Kraft pulp mills also release total reduced sulfur compounds (TRS), the source of the unique kraft mill odor.

2. Releases to Land

Mills generate three types of solid waste: sludge from wastewater treatment plants, ash from boilers and miscellaneous solid waste, which includes wood waste, waste from the chemical recovery system, non-recyclable paper, rejects from recycling processes and general mill refuse. Mechanical and chemical pulp mills generate the same amount of total solid waste.

In some cases, recycling-based paper mills produce more solid waste than do virgin fiber mills. This residue consists almost entirely of inorganic fillers, coatings and short paper fibers that are washed out of the recovered paper in the fiber-cleaning process. Printing and writing paper mills tend to generate the most sludge, while paperboard mills produce the least.

3. Releases to Water

Waterborne wastes are often a focus of environmental concern for a number of reasons. Water-based discharges have the greatest potential to introduce contaminants directly into the environment and the food chain. Water use also correlates with energy use, since it takes energy to pump, heat, evaporate and treat process water.

The effluent from pulp mills contains a complex mixture of organic compounds. Effluent from mechanical pulp mills generally contains less organic waste than that of chemical pulp mills because most of the organic material stays with the pulp. Recovered paper processing systems can contain significant quantities of organic waste in their effluent. This material consists primarily of starches and other compounds that are contained in the recovered paper that the mill uses. Kraft pulp mill effluent contains a mixture of degraded lignin compounds and wood extractives. Bleached kraft pulp mill effluent may also contain chlorinated organic compounds, depending on the amount of chlorine compounds used in the bleaching process.

Mills use several analytical tests to learn more about this mix of organic substances. These tests include biochemical oxygen demand (BOD), color, chemical oxygen demand (COD), adsorbable organic halogens (AOX) and dioxins.

Pollution-Control Technologies

Pollution-control technologies remove specific pollutants from mills' air emissions, solid waste or effluent. Brief descriptions of widely used control technologies follow.

1. Air Emissions

There are three control technologies that remove specific substances from the air emissions of pulp and paper mills. Electrostatic precipitators physically remove fine particulates. Scrubbers chemically transform gaseous sulfur dioxide, chlorine and chlorine dioxide so that they stay in the scrubber's chemical solution. Mills route combustible gases, including total reduced sulfur compounds, to the chemical recovery system or to power boilers, where they are burned as fuel.

2. Solid waste Disposal

Mills send more than 70% of their solid waste to landfills, most of which are company-owned. Some mills incinerate wood waste and wastewater sludge, while others are testing beneficial uses for wastewater sludge such as land application and landfill covering.

Residue from recycled-paper based mills is usually landfilled in a secure, lined facility. The amount of residue generated by a mill is partly a function of the quantity of contaminants in the incoming recovered paper. The design of processes within the mill, however, can improve the potential for reusing the mill residue. Some manufacturers of 100% recycled paperboard, for example, use the fibrous residue from their process in the middle layers of their multi-ply sheet. Many recycled paper manufacturers are trying to find ways to separate the materials in mill residue into products that can be beneficially reused.

3. Effluent Treatment

The wastewater from all but one mill in the United States undergoes two stages of treatment before it is discharged. Primary treatment removes suspended matter in the effluent. These wastes, which consist mainly of bark particles, fiber debris, filler and coating materials,[27] leave the system as sludge.

Secondary treatment systems use microorganisms to convert the dissolved organic waste in the effluent into a more harmless form. These systems generally remove 90-95% of the BOD in the effluent. Although primarily designed to remove BOD, secondary treatment also reduces the loading of COD and AOX. Effluent discharged from a well-run secondary treatment system is not acutely toxic to aquatic organisms.

Secondary treatment systems also generate sludge, which consists mainly of the organic remains of the bacteria. Dioxins and other compounds that do not dissolve in water are often transferred to the sludge during secondary treatment.

Pollution-Prevention Technologies for Pulp and Paper Manufacturing

In contrast to pollution-control approaches, pollution-prevention approaches minimize releases of waste to the environment through technology changes, process control, raw material substitution, product reformulation and improved training, maintenance and housekeeping.

The pulp and paper industry has a tradition of using pollution-prevention approaches. The development of the recovery boiler and associated chemical recovery systems, for example, improved the economics of the kraft pulping process and helped make it the dominant pulping process in the world. These systems also reduced discharges of chemicals to the environment, because they allow the pulping chemicals to be recirculated and reused within the mill.

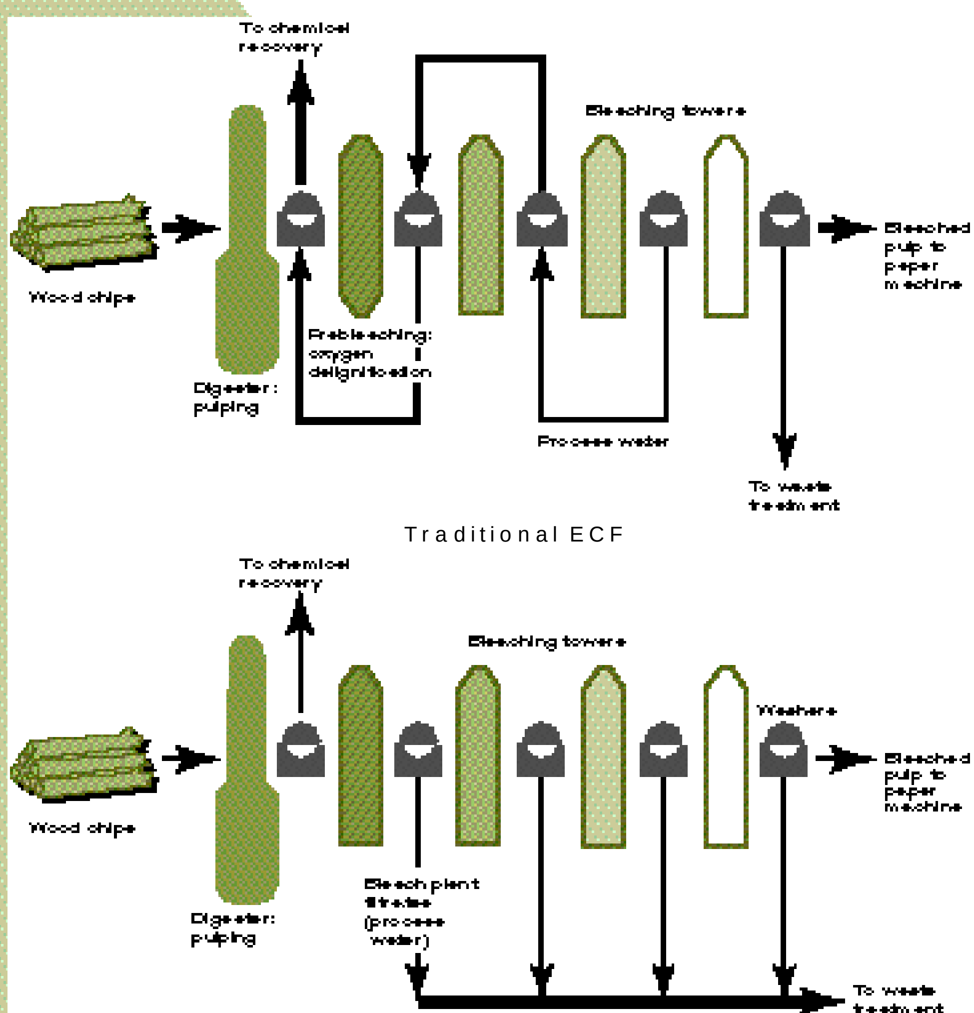
The types of pulp that mills produce determine their approach to pollution prevention. These approaches differ for mechanical and unbleached kraft pulp mills and bleached kraft pulp mills.

1. Mechanical and Unbleached Kraft Pulp Mills

Pollution-prevention approaches for mechanical and unbleached kraft mills primarily focus on improving the operations of the mill, such as spill prevention and water conservation. Incremental improvements in existing mechanical pulping

Figure 7

Ozone ECF



processes, for example, may lead to reduced energy consumption. Unbleached kraft pulp mills can improve the quality of their effluent by improving spill control and upgrading pulp washing to send more of the spent pulping liquor back to the chemical recovery system.

2. Recovered-Fiber Processing Technologies

Pollution-prevention approaches for recovered-fiber processing mills are similar to those for mechanical pulp mills. Both technologies use primarily mechanical energy to separate and process fibers, and neither tend to have large supplies of wood by-products available to burn to create energy. The efficient use of energy is therefore an environmental and economic priority for these mills.

A few mills that make recycled paperboard, linerboard or corrugating medium have virtually closed water systems. The only significant loss of water in these mills is through evaporation on the paper machines. Several mills that deink recovered office paper have designed their processes to use water from paper machines, and thus consume no fresh water.

3. Bleached Kraft Pulp Mills

Pollution-prevention approaches for bleached kraft pulp mills include improvements in mill operations and manufacturing technologies. Today, paper manufacturers are using pollution-prevention approaches to reduce the quantity and improve the quality of effluent from the bleach plant and to reduce energy consumption.

a. Improved Pulping Processes — Extended Delignification and Oxygen Delignification

Extended delignification and *oxygen delignification* remove more lignin from the wood before the unbleached pulp enters the bleach plant. Therefore, fewer bleaching chemicals are required, less organic waste is generated in the bleaching process, less waste treatment is necessary and discharges per ton of pulp manufactured are lower. Energy use also is lower because additional organic material removed from the pulp can be burned in the recovery boiler instead of being discharged, and because more heated process water is recirculated within the mill.

To extend delignification in the pulping process, new digesters can be installed or existing digesters can be modified to increase the length of time that wood chips are cooked. This removes more lignin without compromising the strength of the pulp. The addition of certain chemicals such as anthraquinone in the pulping stage can have a similar effect.

Oxygen delignification systems employ oxygen to remove additional lignin after the wood chips have been cooked in the digester but before the pulp enters the bleach plant. The filtrates from the pulp washers following the oxygen delignification step are routed to the chemical recovery system.

It is important to note that all mills worldwide currently using TCF or ozone-ECF bleaching technologies, which are described in more detail below, also employ extended delignification, oxygen delignification or both. The one chloride-removal technology now being tested in a mill-scale demonstration is designed for mills with an ECF process that also uses oxygen delignification. *The removal of additional lignin prior to the bleaching process is an essential foundation for the cost-effective operation of these technologies.* Without the removal of additional lignin using extended delignification or oxygen delignification prior to bleaching, too much material is present for the cost-effective use of the oxygen-based bleaching compounds or chloride removal processes.

b. Improved Bleaching Processes-–Substitution of Chlorine Dioxide for Elemental Chlorine

Some bleached kraft pulp mills are improving the quality of their effluent by replacing elemental chlorine with chlorine dioxide. The substitution of chlorine dioxide for 100% of the elemental chlorine used in the bleaching process is one form of elemental chlorine-free (ECF) bleaching. We refer to this process as *traditional ECF* bleaching throughout the chapter. (Chlorine dioxide can also replace chlorine at less than 100% substitution). This improved bleaching process reduces the formation of many chlorinated organic compounds during the bleaching process. However, the quantity of effluent from the mill is not reduced. Further progress in reducing the quantity and improving the quality of the effluent ultimately depends on installing an improved pulping process or one of the technologies described below. Other technologies that reduce effluent quantity may become available in the future.

Mills also operate ECF bleaching processes with improved pulping processes, such as oxygen delignification and/or extended delignification. We refer to these pulp manufacturing processes as *enhanced ECF* processes throughout the chapter.

c. Low-Effluent Processes — Ozone ECF, Totally Chlorine-free Bleaching and Chloride Removal Processes

A key impact of using chlorine and/or chlorine dioxide in the bleaching process is that chlorides in the bleach plant filtrates (the process water removed from the pulp in each washing stage) make the filtrates too corrosive to be sent to the chemical recovery system. If steam from a corrosion-caused pinhole crack in the pipes at the top of the recovery boiler reaches the smelt, the recovery boiler can explode.[28] Therefore, wastewater from the bleach plant that contains chlorinated compounds is not sent through the chemical recovery system, but is treated and discharged to the receiving waters.

Replacing chlorine compounds in the bleaching process with oxygen-based compounds reduces the corrosiveness of the wastewater from each stage of the bleaching process in which the substitution is made. This allows bleach plant filtrates to be sent back through the mill's chemical recovery system and reused instead of being treated and discharged. One way to remove chlorides is to substitute ozone for chlorine or chlorine dioxide in the first stage of the bleaching sequence, thus allowing the filtrates from the first bleaching and extraction stages to be recirculated to the recovery boiler.

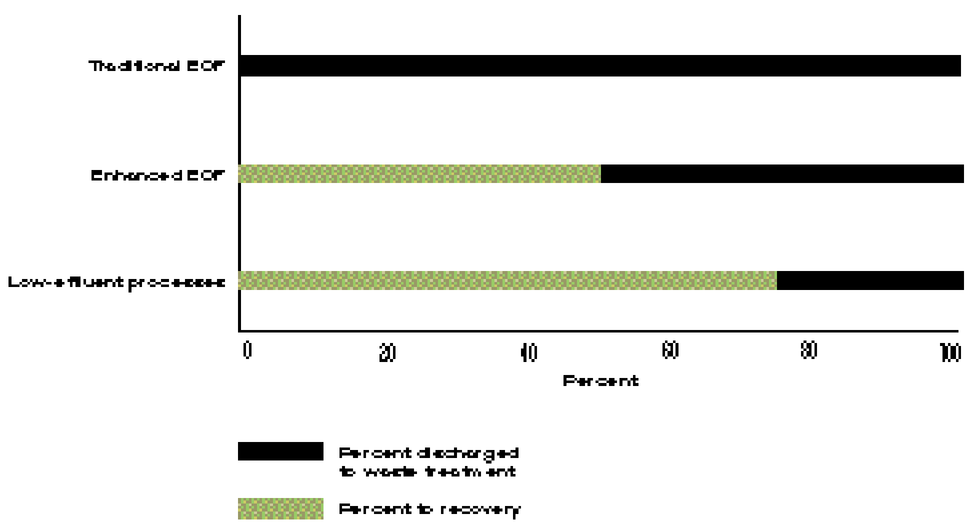
In the last stage of ozone-based ECF bleaching systems, chlorine dioxide is used to brighten the pulp. This is a low-effluent process because only the last bleaching stage uses fresh water that is discharged to the treatment plant; the ozone stage removes most of the remaining lignin. Figure 7 compares the path of bleach plant filtrates in a low-effluent ozone ECF and a traditional ECF process.

Totally chlorine-free (TCF) bleaching processes go one step further than ozone ECF processes to replace all chlorine compounds in the bleaching process with oxygen-based chemicals such as ozone or hydrogen peroxide. TCF processes currently offer the best opportunity to recirculate the filtrates from the entire bleach plant because they have eliminated chlorine ıpounds from all bleaching stages; however, few mills ırrently operate TCF processes in a low-effluent mode. Commercial-scale TCF processes are relatively new. Mills installing these processes typically discharge the filtrates when they first install the processes, and plan to move to low-effluent processes over time.

Add-on technologies that remove the chlorides from the mills' process water using additional evaporating and chloride-removal equipment are in earlier ages of development. Rather than *substitute* bleaching ıpounds like ozone for chlorine dioxide, these processes t reduce the use of chlorine dioxide, but seek to remove des from wastewater with additional processing steps. Unlike the ozone ECF or TCF processes, the chloride removal processes generate an additional waste product that must be disposed. A mill-scale demonstration of a process technology to remove chlorides from the process water of a mill with oxygen delignification and ECF bleaching began in September 1995.

Figure 8

Flows of Waterborne Waste for Bleached Kraft Pulp Manufacturing Processes



d. Environmental Performance

Installing pollution-prevention technologies at bleached kraft pulp mills reduces the releases to the environment and potential environmental impacts from the mill's effluent. Because hardwoods have lower lignin contents, the estimates of AOX and COD for hardwood bleach plant filtrates with traditional ECF bleaching will be similar to those of softwood bleach plant filtrates with enhanced ECF.

We present a schematic diagram of the flows of waterborne waste for three classes of bleached kraft pulp manufacturing technologies in Figure 8.

As the diagram shows, in traditional ECF bleaching processes, all of the remaining lignin in the unbleached pulp is removed in the bleaching process and leaves the mill in the effluent. Mills that employ enhanced ECF and low-effluent technologies recirculate more filtrates that contain wood waste to the chemical recovery system, and less organic waste leaves the mill in the effluent. With enhanced ECF processes, for example, about 50% of the remaining lignin is removed during the oxygen delignification or extended delignification step. We present additional information about the environmental and economic performance of these process technologies in Recommendation 3, as well as a broader discussion of the economic and environmental context for these issues in the next section of this chapter.

4. Bleached Sulfite Pulping Processes

Bleached sulfite mills that use chlorine compounds face similar challenges as do bleached kraft mills. Most bleached sulfite mills that have replaced elemental chlorine in their bleach plants have installed TCF bleaching processes.[29] As discussed in the overview of pulp and paper manufacturing, sulfite mills consume less chemicals to produce bright pulp, so these mills can achieve similar functional performance economically with TCF processes. Sulfite mills with chemical recovery systems are also working on recirculating bleach plant effluent to the chemical recovery system. One Swedish sulfite mill currently operates its bleach plant in an effluent-free mode.[30]

5. Technologies in Research and Development

Pulp and paper manufacturers, their equipment and chemical suppliers, and research institutions have active research programs in new pulping, bleaching, bleach-filtrate recovery technologies and chemical-recovery systems. *Agenda 2020*, a research agenda developed by the American Forest & Paper Association, provides additional detail on some of the specific areas of research.[31] New pulping processes include the addition of polysulfide to digesters to improve delignification. New bleaching agents include enzymes, peracids, activated oxygen and novel metallic compounds. Laboratory research continues on bleach-plant filtrate recovery as researchers explore other ways to separate the water from the organic and inorganic waste in the bleach plant filtrates.[32] Manufacturers are also investigating metallurgy in recovery boilers that would allow for increased combustion of chlorinated waste products.

Active research and commercialization are underway in a number of areas for recycling-based manufacturing systems. These include technologies, for example, that use additional mechanical and chemical steps to remove contaminants; relatively small, modular deinking systems that can be installed as one complete unit; and means of separating and/or beneficially reusing different elements in mill solid-waste residuals.

Environmental Management Systems

Environmental management systems (EMS) are also an important part of the pollution-prevention approach. Mills with sound environmental management get the best performance out of their existing manufacturing processes and minimize the impacts of process upsets, equipment failure and other accidents. At a minimum, implementing environmental management systems should make it easier for mills to comply with environmental laws and regulations. Manufacturers may also design these systems to encourage innovation that takes them beyond compliance.

For pulp and paper manufacturers, effective environmental management systems include spill prevention and control, preventive maintenance, emergency preparedness and response, and energy-efficiency programs. These programs reduce both the likelihood of serious accidents and their potential impact on mill personnel, the local community and the environment.

Spills of spent pulping liquor increase the waste load that must be handled by the effluent-treatment facility and thus may lead to increased amounts of organic waste in mill wastewater. Mills can install additional storage tanks to contain the spills until the spent liquor is returned to the chemical-recovery system, and can train their staff to prevent or minimize spills. Improved washing and closed screen rooms further reduce the quantity of spent pulping liquor that is sent to the treatment facility.

Preventive-maintenance programs identify and repair equipment before it fails. These programs avoid equipment or system failure that can lead to large releases to the environment or other emergencies that affect mill personnel or the community nearby. Emergency preparedness and response programs ensure that the mill and the community can respond to an accidental release of hazardous chemicals at the mill.

To some extent, a mill's manufacturing technologies determine its energy consumption. However, mills can take advantage of energy-saving technologies that range from installing more efficient electric motors to replacing old digesters. Technologies exist that increase heat recovery in mechanical pulping and in papermaking processes. Research continues to develop processes that reduce the energy consumption of paper machine dryers, recovery boilers and evaporators.

Training and internal auditing programs are also important components of an environmental management program. Training programs ensure that employees understand the importance of these practices and how to implement them. Internal audits allow suppliers to assess the performance of the environmental management system. The International Standards Organization (ISO) has recognized the importance of environmental management systems. As a result, a committee has been working on an international standard, ISO 14001, that will define the key elements of an effective system for all manufacturers. These elements include:[33]

- A vision defined in an environmental policy
- Objectives and targets for environmental performance

- Programs to achieve those targets
- Ways to monitor and measure the system's effectiveness
- Ways to correct problems
- Periodic review of the system to improve it and overall environmental performance

ISO has elevated ISO 14001 to "draft international status," a step away from a final standard. Once the standard has been accepted, manufacturers may ask independent auditors to certify that they have installed an environmental management system that meets the standard. Thus ISO 14001 focuses on the management *process,* not on its *content and performance.* Each manufacturer determines its own goals, objectives and programs to achieve continuous environmental improvement.

III.› ENVIRONMENTAL AND ECONOMIC CONTEXT FOR THE RECOMMENDATIONS

Environmental Context

In response to environmental regulations in the 1970's, pulp and paper mills in the United States installed pollution-control technologies to remove specific pollutants from their air and water releases. Since 1970, the pulp and paper industry has reduced overall air emissions of sulfur dioxide by 30%, total reduced sulfur compounds by 90% and the loadings of biochemical oxygen demand and total suspended solids in the final effluent by 75-80%. Water conservation programs have reduced overall mill water consumption by about 70% since 1970.[34] Between 1970 and 1993, total production of pulp and paper has increased by 67%.[35] The industry responded to the discovery of dioxin in its wastewater by implementing a combination of process and technology changes. According to the AF&PA, this effort has reduced dioxin levels from all bleached chemical pulp mills by 92% since 1988.

Pollution prevention is a more conservative approach to environmental protection than pollution control. We do not know everything about the effluent from pulp and paper mills, nor can we measure all of its potential effects on the environment. Scientists are continuing to find new substances in the complex mixture of organic material that is discharged in pulp mill effluent. For example, wood contains minute amounts of powerful chemical substances that aid in the growth of a tree and protect it from pests. The pulping process concentrates these substances as mills convert about 4.5 tons of trees into 1 ton of bleached kraft pulp at a scale of 1,000 to 2,000 tons of pulp per day. As long as mills discharge effluent, these substances are likely to be released into mills' receiving waters.[36]

As of February 1994, scientists had identified 415 compounds in bleached kraft pulp mill effluent.[37] These represent a fraction of the total number of compounds present.[38] It is unlikely that we will ever have a complete understanding of the toxic effects of these compounds individually, let alone their effects as a mixture. For example, of the 70,000 chemicals currently sold on the market, adequate toxicological data are available for about 10 to 20%.[39]

Field studies of the environmental effects of the effluent, while important, may not provide a complete picture of impacts. These biological and ecological studies are expensive and complex, and they are often highly limited in their ability to show specific cause-and-effect relationships.[40] Certain problems may be discovered years after a class of pollutants has built up in the environment. Biological assays are usually able to detect acute or chronic effects from pulp and paper mill effluent (for example, the death or impaired growth of certain species of fish, invertebrates or plants). However, they may not be capable of detecting longer-term changes, such as gradual changes in the number or types of the plants and invertebrates that live on the bottoms of rivers that support the entire ecosystem.

The discovery of dioxin in the effluent of bleached kraft pulp mills in 1985, for example, was not anticipated by studies performed in labs and at mill sites. This discovery generated a great deal of public attention and led paper manufacturers to rapidly invest a total of $2 billion in an effort to reduce discharges of dioxin to below levels that are detectable with standard lab tests. Pollution-prevention approaches can help reduce the probability of this type of unwanted surprise in the future.

Economic Context

Since 1970, the U.S. pulp and paper industry has invested over $10 billion in pollution-control technologies. As of 1994 it was investing more than $1 billion per year in capital costs for additional systems. Annualized total costs for environmental protection range from $10 to $50 per ton of production, depending on the type and size of the mill.[41] The reduction of releases to the environment through "end-of-the-pipe" treatment has led many to think that improved environmental performance is at odds with improved economic performance. Pollution-treatment systems usually increase capital and operating costs without improving the productive output of the mill.

The difference between pollution prevention and pollution control has an analogue in the comparison of total quality management programs with quality control based on inspection for defects in finished products. Before firms designed quality into their products and processes, defects were seen as an inevitable by-product of the manufacturing process, not as a sign of inefficient product and process design.[42] By designing manufacturing processes that have targets of zero defects, companies have improved the quality of their products and their profitability. Improved product quality increased sales and lowered the costs associated with undesired outcomes after products had been sold, such as customer complaints and repairs.

By using pollution-prevention approaches, suppliers can design environmental improvement into manufacturing processes. Michael Porter, an expert on competitive strategy at the Harvard Business School, observes that "[l]ike defects, pollution often reveals flaws in the product design or production process. Efforts to eliminate pollution can therefore follow the same basic principles widely used in quality programs: Use inputs more efficiently, eliminate the need for hazardous, hard-to-handle materials and eliminate unneeded activities."[43]

A recent study has documented the economic benefits of installing technologies or modifying processes that use resources more efficiently. Chad Nerht, of the University of Texas at Dallas, studied 50 bleached kraft pulp and paper manufacturers in six countries. He found that the longer a firm had invested in extended delignification and ECF and TCF bleaching technologies, the better its economic performance. Those companies that invested both earlier and more substantially had higher income growth, even taking into consideration national differences in regulations, capacity utilization and general growth in the economy, sales and wages.[44]

Timing

Shifting from a focus on pollution control to pollution prevention takes time, money and a more holistic approach to managing the environmental issues associated with pulp and paper manufacturing. Mills operate large pieces of equipment that have long, useful lives. The need to fully utilize this equipment reduces paper manufacturers' flexibility in investing in new pulp manufacturing technologies. For example, the investment in additional chlorine dioxide capacity required for traditional ECF processes may make mills reluctant to invest in oxygen or extended delignification, technologies that would reduce future chlorine dioxide needs.

Pollution-prevention investments also compete for capital funds along with other projects that will improve the company's profitability. Moreover, making investments in technologies that do not turn out to be competitive over their life-span can be very costly.

If individual mills make technology investments in order to meet special requests from purchasers and their manufacturing costs increase in the process, they will seek to charge a price premium for their products. The price premium allows the mill to maintain comparable profit margins for different products. Whether such price premiums will be realized depends on overall market conditions and on the number of competing mills making a specific product. If purchasing specifications shift for a large part of the market, mills will have to respond with new technologies in order to remain competitive. If only one or two mills produce a specific product, increased costs are more likely to be passed on to purchasers.

Paper companies routinely consider how much capital they should invest to reduce operating costs. As discussed in Chapter 1, the trend of the last 20 years is toward increased capital intensity in pulp and paper manufacturing, leading to lower operating costs and lower total costs. Both internal and external factors affect the timing and investment in new pulp manufacturing technologies at pulp and paper mills.

Paper manufacturers generally weigh several factors in their capital-allocation decisions.

The paper manufacturer's philosophy toward environmental performance may have the largest effect on capital-allocation decisions.

- The *company philosophy* toward environmental performance may have the largest effect on capital-allocation decisions. Some pulp and paper manufacturers strive to integrate short- and long-term environmental goals along with cost, productivity and quality in every investment decision. For example, a company with a policy of increasing its margin of environmental safety with each investment might expand the capacity of a recovery boiler as part of a required renovation project to accommodate the additional load from an improved pulping process. Without this policy, the company might rebuild a recovery boiler at a bleached kraft mill but not add any new capacity.
- Investing additional capital to reduce operating costs provides the largest economic benefits when mills need *additional pulp capacity*. In this case, the cost savings that result from installing pollution-prevention technologies offset the additional capital expenditure.
- *When a mill needs to replace worn-out equipment*, the company will invest capital in order to continue operating. The company philosophy and opportunities to expand capacity play an important role in the choice of new equipment.
- *Site-specific equipment or space limitations* will increase the capital costs to install pollution-prevention technologies. Capacity limits on key equipment, such as a recovery boiler at a bleached kraft pulp mill, increase the capital costs to install improved pulping or low-effluent bleaching processes. Mills also may have unique equipment arrangements that increase the capital costs to install these processes.
- *Shifts in customer demand and new environmental regulations* are two *external* factors that influence pulp and paper company capital investment decisions. For example, both of these external factors have influenced the industry's commitment to eliminate elemental chlorine from bleached kraft pulp mills.

Most mills experience a combination of the factors described above; as a result, the timing and the range of capital costs to install pollution-prevention technologies will differ for individual mills.

- Mills that produce more pulp than paper will probably add a paper machine before they modify the pulp mill.
- Mills that have average to low capital costs to install pollution-prevention technologies will do so to take advantage of lower operating costs.
- Mills with higher capital costs will wait until the combination of factors improves the economics of this investment.

Appendix B presents a cost model and a range of scenarios to install pollution-prevention technologies at bleached kraft pulp mills.

The large number of bleached kraft pulp mills operating in the United States means that there are probably pulp mills that fit into each of these groups. With 87 bleached kraft pulp mills with 162 fiber lines[45] operating nationwide in 1995, in any given five-year period a number of these lines will be undergoing major renovations or expansions. Replacement of individual pieces of equipment, minor renovations and the elimination of bottlenecks will proceed at an even greater rate. For example, a 1993 survey of recovery boilers found that over 70% were more than 25 years old. These recovery boilers will have to be rebuilt or replaced in the next decade.[46]

The Role for Purchasers

Over time, expressions of preferences by paper purchasers will influence investment decisions and the availability of environmentally preferable paper products in different market conditions. Companies plan their next round of investments when they are earning high cash flows, during the up-side of the paper pricing cycle. Annual capital expenditures usually peak about three years later, because it takes time to plan the projects.

Integrating pollution-prevention strategies into pulp and paper manufacturing will require a highly disciplined capital planning process that integrates a long-term vision for environmental progress with improvements in quality, productivity and lower manufacturing costs. The "minimum-impact mill," a vision of environmental progress, is a key part of the recommendations that follow. The Task Force's recommendations, as expressed through decisions made by individual paper purchasers, will encourage suppliers to maintain this investment discipline.

RECOMMENDATIONS FOR PURCHASING PAPER MADE WITH ENVIRONMENTALLY PREFERABLE PROCESSES

The Paper Task Force's recommendations build upon technologies that provide pollution-prevention benefits and are an integral part of many pulp and paper mills.

As discussed throughout this chapter, pollution prevention is not new to paper manufacturing. Some paper manufacturers have supported pollution-prevention approaches as providing an "extra margin of environmental safety" or as reducing the probability of undesired environmental surprises. Others have emphasized the competitive advantage that comes from more efficient use of resources, lower costs for complying with environmental regulations and the ability to compete more effectively in environmentally sensitive markets such as Europe. These paper suppliers also make the point that "sustainable manufacturing" based on pollution-prevention technologies will help maintain public acceptance of resource-intensive businesses like paper manufacturing over the long term. All of these outcomes are in the interest of paper buyers and users as well as manufacturers.

Recommendations

Minimum-impact Mills

Recommendation 1. Purchasers should give preference to paper manufactured by suppliers who have a vision of and a commitment to minimum-impact mills – the goal of which is to minimize natural resource consumption (wood, water, energy) and minimize the quantity and maximize the quality of releases to air, water and land. The minimum-impact mill is a holistic manufacturing concept that encompasses environmental management systems, compliance with environmental laws and regulations and manufacturing technologies.

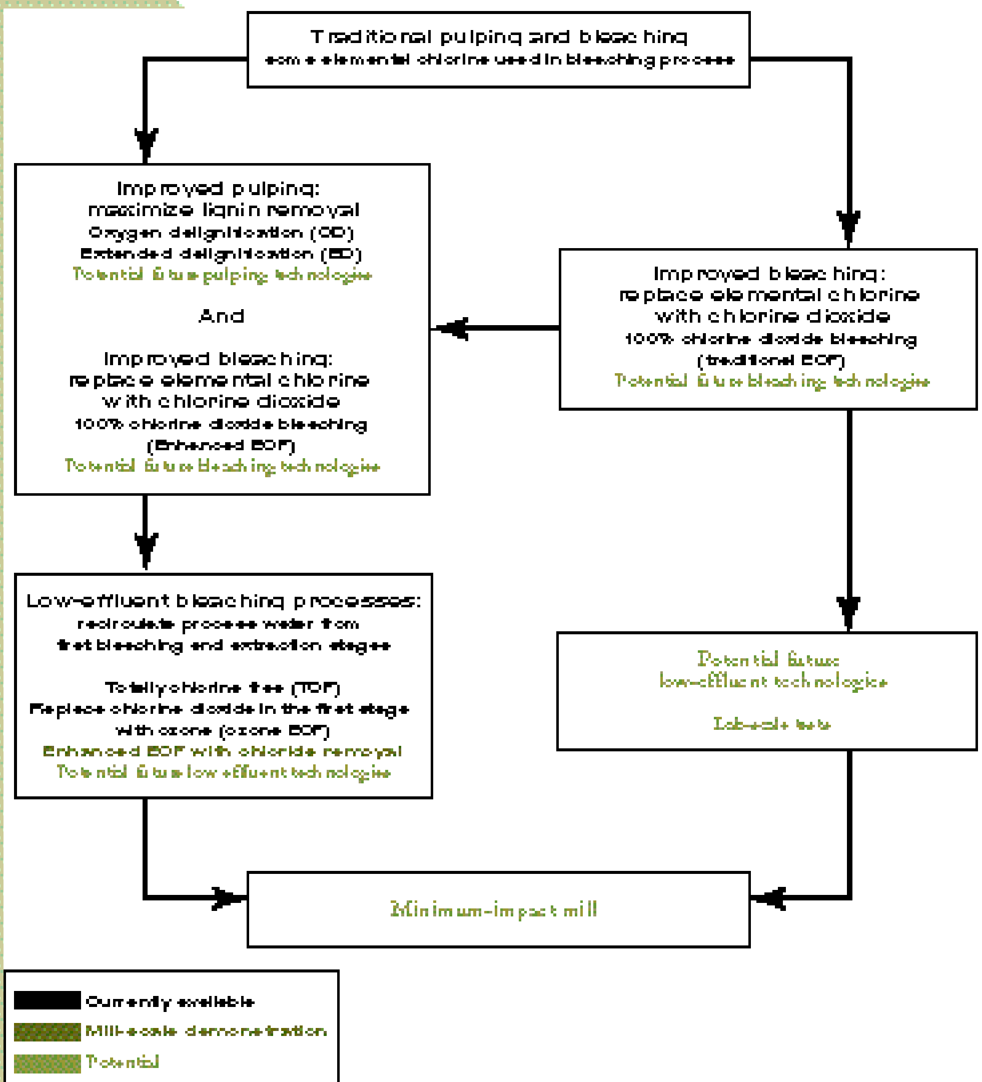
- *Rationale:* Sustainable pulp and paper manufacturing requires a holistic view of the manufacturing process. This concept begins with a vision and commitment to a long-term goal that should guide all decisions about the direction of both the mill operations and the selection of manufacturing technologies. Investing in manufacturing processes that prevent pollution and practicing good environmental management go hand-in-hand. A poorly run mill may not be able to reap the environmental benefits that result from installing advanced pollution-prevention technologies. Outdated manufacturing technologies, however, will limit the ability of a well-run mill to achieve continuous environmental improvement.

  Adopting the long-term goal of operating minimum-impact mills allows suppliers to develop measurable and cost-effective investment strategies that provide environmental benefits and improve economic competitiveness. Pulp and paper mills routinely make investments in individual pieces of equipment and periodically undergo more costly renovations and expansions. The strategic application of the minimum-impact mill concept will allow manufacturers to integrate decisions that affect manufacturing costs, productivity, quality and environmental impacts.
- *Availability/timing:* The minimum-impact mill is a dynamic and long-term goal that will require an evolution of technology in some cases. Many factors will affect the specific technology pathway and the rate at which individual mills will progress toward this goal. These factors include the products manufactured at the mill, the types of wood that are available, the mill's location, the age and configuration of equipment, operator expertise, the availability of capital and the stages a mill has reached in its capital investment cycle. Some mills, for example, will install the most advanced current technologies with a relatively low capital investment within the next five years.

Recommendation 2. Purchasers should give preference to paper products manufactured by suppliers who demonstrate a commitment to implementing sound environmental management

Figure 9

Bleached Kraft Pulp Technology Pathways



Descriptions of these technologies along with information on their environmental and economic performance is presented below.

of their mills. Suppliers should demonstrate progress in the following areas:

- *Improved spill-prevention and control systems based on the installation of available technologies*
- *Preventive maintenance programs*
- *Emergency preparedness and response programs*
- *Improving the energy efficiency of mill operations through the installation of energy-conservation technologies*
- *On-going training for mill staff in process control and their role in improving environmental performance*
- *Internal auditing procedures that include qualitative and quantitative measures of performance*
- *Purchasers should consider their suppliers' compliance records as one indicator of an effective environmental management system.*
- *Rationale for spill prevention and control programs:* Spills of spent pulping liquor increase the waste load that must be handled by the effluent-treatment facility. Maximizing the recovery of the spent pulping liquor also reduces the amount of pulping chemicals that must be purchased and increases the amount of steam generated by the recovery boiler when the organic waste is burned for energy.
- *Rationale for preventive maintenance programs:* Preventive maintenance programs identify and repair equipment before it fails. These programs avoid equipment or system failures that can lead to large releases to the environment or other emergencies that affect mill personnel or the community nearby. Preventive maintenance programs also reduce economic losses due to lost production, premature replacement of equipment and catastrophic incidents.
- *Rationale for emergency preparedness and response programs*: These programs prepare mill staff and the local community for infrequent events that may have serious environmental consequences, such as a recovery boiler or digester explosion or a large release of bleaching chemicals. Quick and effective responses to these events will mitigate their impact on the local communities and the environment.
- *Rationale for energy efficiency:* Energy-efficient mills release lower

levels of air pollutants associated with the combustion process and have lower energy costs. Increasing the efficient use of purchased electricity and fossil fuels reduces the environmental impacts associated with electricity generation and with the extraction of fossil fuels. Reducing the total energy consumption of the mill reduces its carbon dioxide releases. Carbon dioxide, a greenhouse gas, is associated with global climate change.

- *Rationale for increased training:* Without well-trained staff, a mill with the latest process technology and operating procedures cannot achieve optimum environmental or economic performance. By increasing the awareness of the potential impact of mill processes on the environment, suppliers empower their staff to improve the efficiency of the mill's operations.
- *Rationale for internal auditing systems:* Internal auditing systems are a central component of an environmental management system, because they measure its performance. Audits allow mills to quantify improvements over time and to compare their performance with other mills.
- *Availability/timing:* Many pulp and paper manufacturers have implemented environmental management systems and others are doing so in anticipation of the ISO 14001 standards, which are discussed earlier in this chapter. Technologies to improve spill prevention and control are available and can be installed in the near term. Opportunities to install energy-saving technologies arise over time as mills upgrade or replace old equipment. Many suppliers already have extensive training programs in these areas.

Recommendation 3: Purchasers should give preference to paper manufactured by suppliers who demonstrate continuous environmental improvement toward minimum-impact mills by installing pollution-prevention technologies.

- *Rationale:* The manufacturing technologies installed at a pulp or paper mill will eventually limit its environmental performance. Most mills will have to install new process technologies over their productive life spans in order to achieve continuous progress toward the minimum-impact mill. A clear definition of the goals of the minimum-impact mill will guide technology selection over time. The array of available manufacturing technologies differs for each pulp manufacturing process. Descriptions of major technologies for mechanical, unbleached kraft, recycled fiber and bleached kraft pulp mills follow.

  Mechanical pulp mills: Although reducing the relatively low releases to the environment is desirable, reducing the relatively high energy consumption of the pulping process is the primary long-term challenge for mechanical pulp mills.

  Unbleached kraft pulp mills: Progress toward the minimum-impact unbleached kraft mill will build upon the mill's ability to recover the organic waste in the effluent in the recovery boiler. Well-run mills recover 99% of this waste. Incremental improvement will result from improved spill control and washing. Unbleached kraft pulp mills will also modify existing processes to reuse more process water within the mill.

  Recovered fiber pulp mills: Most releases to the environment from recovered fiber pulp mills are comparatively low. Some mills may be able to make progress in reducing their water consumption. Priorities include increasing the efficiency of purchased energy use and handling rejects within the mill to facilitate the generation of usable by-products instead of sludge that has to be landfilled.

  Bleached kraft pulp mills: Pollution-prevention technologies for bleached kraft mills modify the pulping and bleaching processes to improve the quality of their releases to the environment and to enable the process water from the bleach plant to be recirculated to the chemical recovery system, where the used chemicals are recovered and the organic waste is burned for energy in the recovery boiler. The process water is then reused within the mill.

  Figure 9 illustrates pollution-prevention technology pathways that focus on currently available and experimental technologies for bleached kraft pulp mills. Economic and environmental issues and the availability of paper products made using these different technologies are discussed below. Four key ideas that purchasers should consider as they evaluate the technologies at bleached kraft mills are also highlighted.

Economic Assessment of Bleached Kraft Pulp Manufacturing Technologies

Two key conclusions can be drawn from the Task Force's economic analysis of bleached kraft pulp manufacturing technologies. First, purchasers currently do not pay different prices for paper manufactured using traditional pulping and bleaching, traditional ECF, enhanced ECF or ozone ECF technologies. This consistency in market pricing should continue into the future. Market price premiums for TCF paper probably result from a short-term imbalance of supply and demand. The limited availability that results from small production runs at non-integrated mills rather than higher pulp manufacturing costs may cause higher prices.

Second, there is no reason to expect price premiums for paper products manufactured at mills that install ozone ECF or TCF technologies in the future. For existing mills without site-specific limitations, the differences in total manufacturing costs among the array of available technologies are generally small or non-existent. (For a general discussion of price premiums, see Chapter 3.) Installing these technologies is, in fact, likely to reduce manufacturing costs for new mills or for mills that are conducting major renovations or expansions. These topics are analyzed further in Appendix B.

Environmental Assessment of Bleached Kraft Pulp Manufacturing Technologies

The series of charts in Figure 10 compares the performance of six different combinations of kraft pulping and bleaching technologies for softwood pulps across seven environmental parameters: BOD, COD, color, AOX, bleach plant energy consumption, chloroform air emissions and bleach plant effluent flow. Additional data on these and other parameters that can be used to evaluate manufacturing technologies are presented in Appendices A and C. The parameters in Figure 10 are measured *at the bleach plant*. As previously described, reductions to the actual releases to the environment will be achieved by pollution-control systems. The figures show that substituting chlorine dioxide for elemental chlorine reduces the value of several parameters. Additional reductions accrue as more advanced pulping and bleaching technologies are used.

Major conclusions from the environmental comparison of these technologies are summarized below.

Traditional Pulping and Bleaching: Mills with traditional pulping processes and with bleaching processes that contain some elemental chlorine.

Environmental Advantages: Energy consumption is about 75% of that for a mill with a traditional ECF sequence.

Environmental Disadvantages: Mills that use traditional pulping and bleaching processes have the highest releases of BOD, COD, color and AOX of the processes considered in this section. Dioxin levels in the final effluent are often above the detectable limit of 10 parts per quadrillion (10 ppq). Air emissions of chloroform are also highest.

1. The substitution of chlorine dioxide for elemental chlorine in the first stage of the bleaching process reduces the discharge of chlorinated organic compounds.

Traditional ECF: Mills with traditional pulping processes that have substituted 100% chlorine dioxide for elemental chlorine in the first bleaching stage.

Environmental Advantages: An ECF bleaching process provides improvement in effluent quality (AOX) and in air emissions of chloroform in comparison to a bleaching process with traditional pulping and bleaching. The dioxin level in the final effluent is below a detection limit of 10 parts per quadrillion (ppq), but furans are occasionally found above this detection limit in the bleach plant filtrates, which are more concentrated than the final effluent.

Environmental Disadvantages: The traditional ECF process consumes the most total and purchased energy of the available and proven technologies. Dioxins are also sometimes found in the pulp mill sludge above the limit of detection of 1 part per trillion. Mills with traditional ECF processes would currently have to install oxygen delignification and/or extended delignification to achieve additional improvement.

2. The installation of oxygen delignification and extended cooking, two available and proven cost-effective manufacturing technologies that maximize lignin removal in the pulping process, forms a foundation for further progress toward the minimum-impact mill.

Enhanced ECF: Mills that have installed oxygen delignification and/or extended delignification processes along with 100% chlorine dioxide substitution bleaching.

Environmental Advantages: The quantity of bleach plant effluent from a mill with an enhanced ECF process is typically half that of a mill with a traditional ECF process. Reducing the

lignin content of the pulp before the first bleaching stage reduces the amount of bleaching chemicals used and results in lower total and purchased energy consumption and an improvement in the effluent quality compared to traditional ECF. The dioxin level in the final effluent is below a detection limit of 10 parts per quadrillion (ppq), but furans are occasionally found above this detection limit in the bleach plant filtrates, which are more concentrated than the final effluent.
Environmental Disadvantages: Increased reuse of process water may result in higher hazardous air pollutant emissions from process sources.

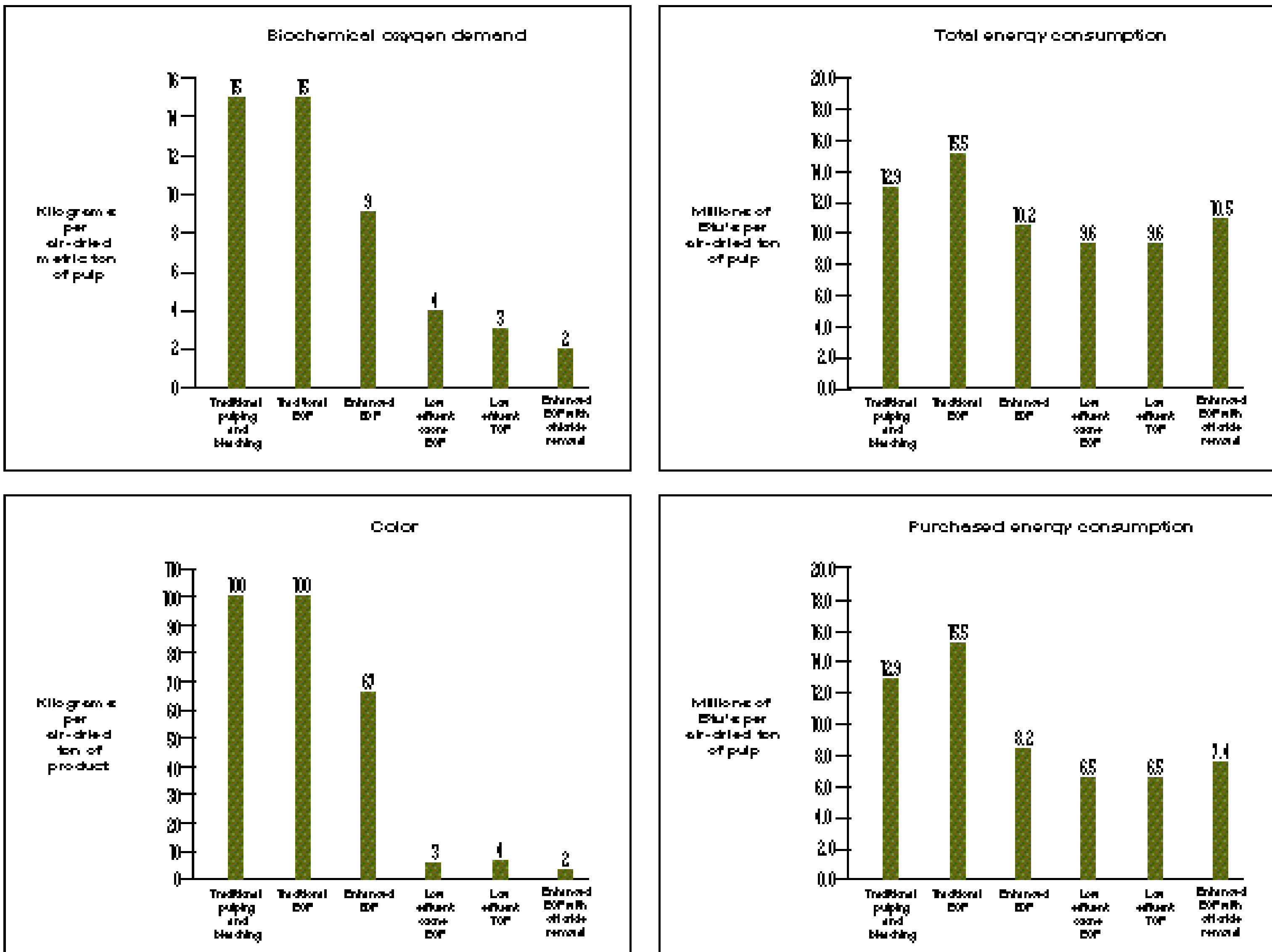
3. Mills that recirculate the filtrates from the first bleaching and extraction stages of the bleach plant make additional progress toward the minimum-impact mill. These low-effluent processes represent the most advanced current technologies.
Ozone ECF: Mills that have substituted ozone for chlorine dioxide in the first stage of an enhanced ECF process.
Environmental Advantages: Mills with enhanced ECF processes that replace chlorine dioxide with ozone in the first bleaching stage can reduce the volume of bleach plant effluent by 70-90% relative to traditional ECF processes by recirculating the filtrates from the first bleaching and extraction stages to the chemical recovery system. Low-effluent ozone ECF and TCF processes have the lowest energy consumption in the bleach plant of the available technologies. Installing low-effluent processes improves the effluent quality in comparison to that of a traditional ECF process. Dioxins (including furans) are not detectable at a limit of 10 ppq in the bleach plant filtrates and may not be generated.
Environmental Disadvantages: Increased reuse of process water may result in higher hazardous air pollutant emissions. Metal concentrations increase as process water is reused, and can affect the process. Currently mills with ozone processes discharge some of the filtrate from the ozone stage to control the concentration of metals. As mills continue to reduce the volume of bleach plant effluent, metals may be disposed of with solid waste from the chemical recovery system.
Totally chlorine-free (TCF): Mills that have replaced elemental chlorine and chlorine dioxide with ozone and/or hydrogen peroxide. Improved pulping processes, such as oxygen delignification and/or extended delignification precede TCF bleaching processes.
Environmental Advantages: Mills with TCF processes can achieve similar reductions in bleach plant effluent volume as mills with ozone ECF processes, if they recirculate the filtrates from the first bleaching and extraction stages to the chemical recovery system. Mills with low-effluent TCF processes achieve similar reductions in BOD, COD and color, and AOX levels are at background levels. Dioxins are not expected to be generated during TCF bleaching processes because no source of elemental chlorine is present. Low-effluent ozone ECF and TCF processes have the lowest energy consumption in the bleach plant of the available technologies.
Environmental Disadvantages: Increased reuse of process water may result in higher hazardous air pollutant emissions. Metal concentrations increase as process water is reused, and can affect the process. Estimates of increased wood requirements for TCF processes range from 0%-11%[47] in comparison to the wood requirements for an ECF process with traditional pulping.

Mills that recirculate the filtrates from the first bleaching and extraction stages of the bleach plant make additional progress toward the minimum-impact mill. These low-effluent processes represent the most advanced current technologies.

Enhanced ECF with chloride removal: An experimental low-effluent process that modifies a mill with an enhanced ECF process to allow it to recirculate bleach plant filtrates in the chemical recovery system. The mill installs equipment to remove the chloride that the bleach plant filtrate brings into the chemical recovery system. A mill-scale demonstration of this add-on technology began in September 1995 and is expected to be completed in June 1997. If the demonstration is successful, then the mill will continue normal operations with the new technology in place.
Environmental Advantages: Enhanced ECF with chloride removal is expected to achieve similar reductions in bleach plant effluent volume and improvements in effluent quality comparable to those that result from low-effluent ozone ECF processes. Total and purchased energy consumption are projected to be lower than that of a traditional ECF process. Total energy consumption is expected to be slightly higher than that for an enhanced ECF process; however, the purchased energy consumption is expected

Figure 10

Estimates of Environmental and Process Indicators for Bleached Kraft Pulp Manufacturing Technologies



Key

Traditional pulping and bleaching: Mills with traditional pulping processes and with bleaching processes that contain some elemental chlorine. In this case, the first bleaching stage uses 50% chlorine dioxide and 50% elemental chlorine.

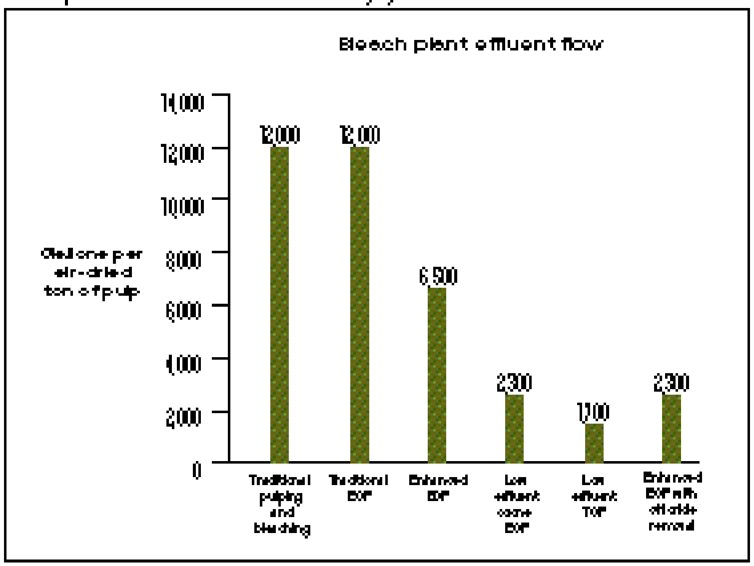
Traditional ECF: Mills with traditional pulping processes that have substituted 100% chlorine dioxide for elemental chlorine in the first bleaching stage.

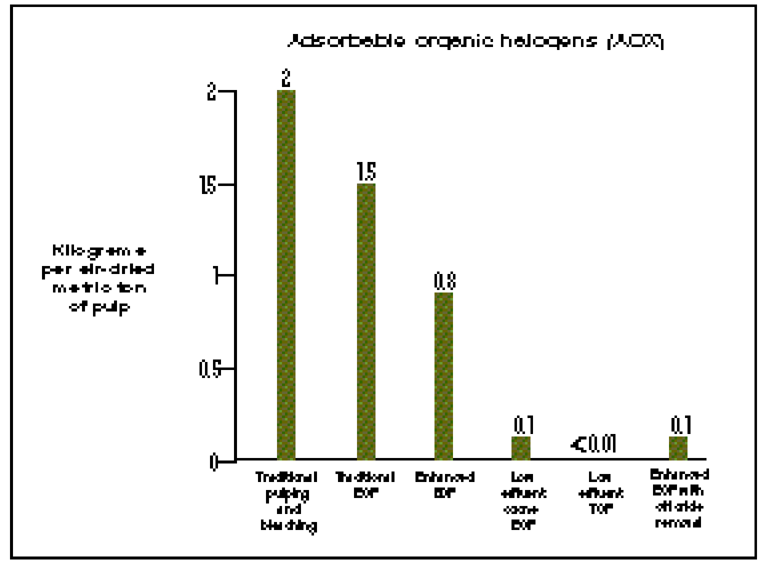
Enhanced ECF: Mills that have installed oxygen delignification and/or extended delignification processes along with 100% chlorine dioxide substitution bleaching.

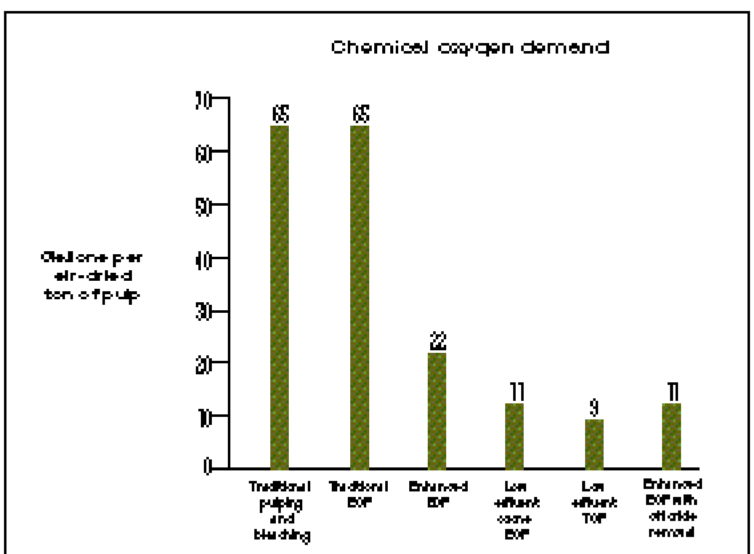
Low-effluent ozone ECF: Mills that have substituted ozone for chlorine dioxide in the first stage of an enhanced ECF process and recirculate bleach plant filtrates from the first bleach and extraction stages to the chemical recovery system.

Low-effluent totally chlorine-free (TCF): Mills that have installed oxygen delignification and/or extended delignification and replaced elemental chlorine and chlorine dioxide with ozone and/or hydrogen peroxide. These mills also recirculate bleach plant filtrates from the first bleaching and extraction stages to the chemical recovery system.

Enhanced ECF with chloride removal: An experimental low-effluent process that modifies a mill with an enhanced ECF process to allow it to recirculate bleach plant filtrates to the chemical recovery system.







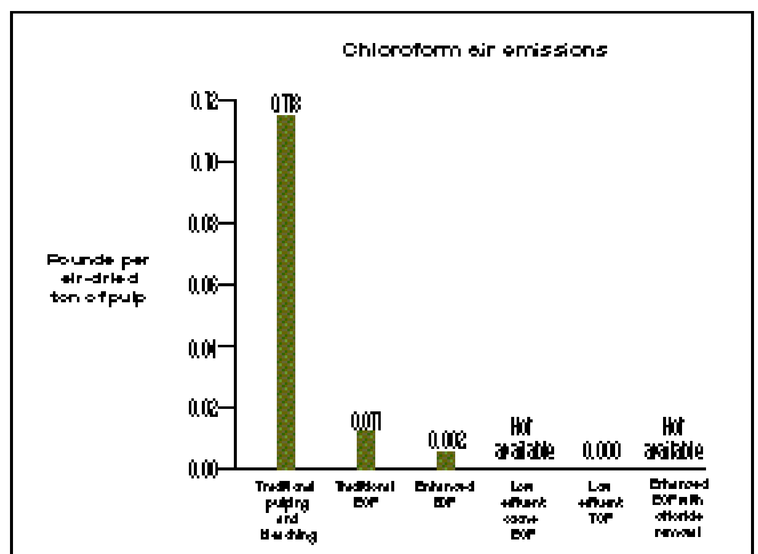
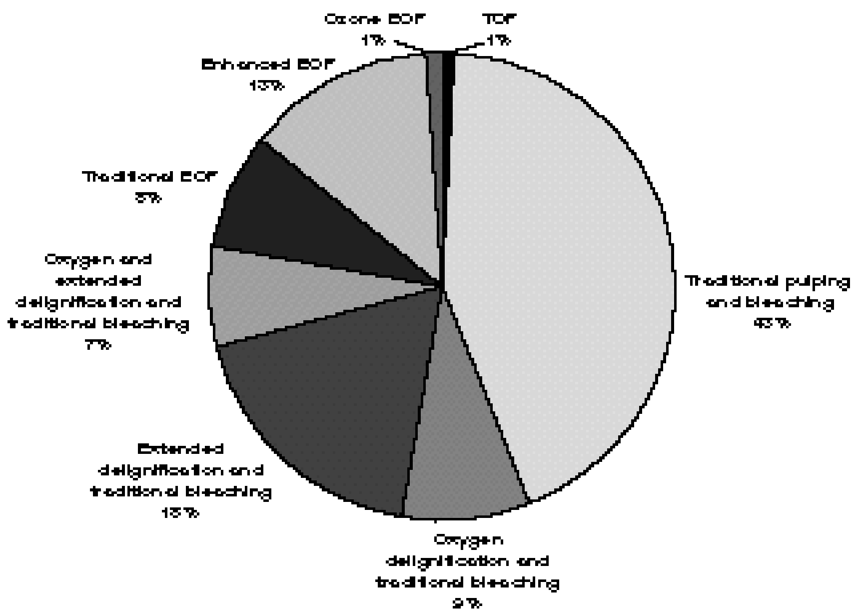


Figure 11

Estimates of 1994 Bleached Kraft Pulp Production



Total Production = 27.1 million metric tons

Key

Traditional pulping and bleaching: Mills with traditional pulping processes and with bleaching processes that contain some elemental chlorine.

Traditional ECF: Mills with traditional pulping processes that have substituted 100% chlorine dioxide for elemental chlorine in the first bleaching stage.

Enhanced ECF: Mills that have installed oxygen delignification and/or extended delignification processes along with 100% chlorine dioxide substitution bleaching.

Low-effluent ozone ECF: Mills that have substituted ozone for chlorine dioxide in the first stage of an enhanced ECF process and recirculate bleach plant filtrates from the first bleaching and extraction stages to the chemical recovery system.

Low-effluent totally chlorine-free (TCF): Mills that have installed oxygen delignification and/or extended delignification and replaced elemental chlorine and chlorine dioxide with ozone and/or hydrogen peroxide. These mills also recirculate bleach plant filtrates from the first bleaching and extraction stages to the chemical recovery system.

Enhanced ECF with chloride removal: An experimental low-effluent process that modifies a mill with an enhanced ECF process to allow it to recirculate bleach plant filtrates in the chemical recovery system.

to be somewhat lower than that of an enhanced ECF process because of the energy savings that result from the steam generated from the recovery of additional organic material.

Environmental Disadvantages: Increased water reuse may result in higher hazardous air pollutant emissions from process sources. The combustion of chlorinated organic compounds in the recovery boiler may result in air emissions of dioxins. The mill-scale demonstration will monitor the air emissions to investigate these potential releases.

4. Future technologies may emerge that make additional progress toward the minimum-impact mill.

The pace of research and development of new technologies has quickened dramatically in the last five years, giving manufacturers more options to consider. *Agenda 2020*, a research agenda proposed by the American Forest & Paper Association, provides an indication of the trends in research on future technological advances.

Figure 9 depicts two groups of experimental technology pathways. Chloride removal technologies are currently undergoing a mill-scale demonstration. Other potential future technologies are being tested at the laboratory and the pilot plant scale. As described in previous sections, these technologies include novel bleaching agents and other process modifications. These new technologies are in different phases of development, and it is difficult to predict when they will become commercially available. Purchasers should recognize that new technologies in pulp and paper manufacturing do not provide benefits to the environment until they are actually running at a commercial scale. In the paper industry, technologies usually require a minimum of five to ten years of laboratory and pilot plant testing before they reach mill-scale demonstration. Technologies such as oxygen delignification and ozone bleaching took about 20 years from initial laboratory demonstration to successful commercial application, for example.

Availability:

Figure 11 shows the production of different types of bleached kraft pulps in the United States in 1994. Paper products manufactured using 100% chlorine dioxide substitution alone and with different combinations of extended delignification and oxygen delignification make up approximately 25% of that production. Paper made using traditional and enhanced ECF pulping and bleaching processes are expected to increase.

Thirty-four percent of bleached kraft pulp produced in the United States in 1994 was manufactured using extended delignification, oxygen delignification or both but still using some elemental chlorine. Most, if not all, of these producers are poised to eliminate elemental chlorine from their processes. As a result of this change, close to half of all bleached kraft pulp in the United States would be manufactured using enhanced ECF processes.

For manufacturers using traditional ECF processes, currently about 8% of production, sunk investments in chlorine dioxide generation capacity will tend to weigh against installing extended or oxygen delignification. Installing these improved pulping technologies would idle some of the chlorine dioxide generating capacity.

Ozone ECF and TCF pulps currently are not widely available, but this will change over time. In 1994, one U.S. mill produced about 300,000 metric tons of bleached softwood kraft pulp using a low-effluent ECF process with ozone bleaching. In 1996, another two U.S. mills will produce bleached kraft hardwood pulp with an ECF process using ozone bleaching. In 1994, one U.S. mill produced about 200,000 metric tons of bleached softwood kraft pulp using a low-effluent TCF process. Several Scandinavian bleached kraft pulp mills operate low-effluent TCF processes. The available quantity of TCF bleached kraft pulp will increase by as much as 900,000 metric tons in 1997 when two new Scandinavian bleached kraft mills begin operation, including one mill with a virtually closed water system.

Product Reformulation by Changing the Types of Pulps Used in Paper Products

Recommendation 4. Purchasers of paper packaging, such as corrugated boxes and folding cartons, should seek to purchase paper products made of unbleached kraft paperboard rather than bleached kraft paperboard in cases where the packaging meets functional and economic requirements.

- *Rationale:* Because the manufacturing process has fewer steps, unbleached kraft pulp production has lower energy consumption and environmental releases than does the production of bleached kraft pulps. Figure C-1 and Table C-1 in Appendix C present a more detailed comparison of the environmental performance of coated bleached and unbleached kraft paperboard. Unbleached kraft pulp also uses wood more efficiently than bleached kraft pulp and is generally stronger. Case studies of companies that have made these packaging shifts have shown that consumer acceptance and overall performance needs can readily be met.
- *Availability/timing*: Coated unbleached kraft for folding cartons is available today. Unbleached linerboard is often substituted for white-lined boxes. Switching to these materials allows the purchaser to achieve environmental benefits in the near term and will generally reduce costs.

Recommendation 5. Purchasers of coated printing and writing papers should express their preference for paper that increases the substitution of mechanical pulp for bleached kraft pulp in cases where the paper meets functional and economic requirements.

- *Rationale.* All coated printing and writing papers contain softwood bleached kraft pulp to avoid paper breaks during the printing process. Coated groundwood papers typically contain an equal mix of softwood bleached kraft and groundwood pulps. Environmentally preferable coated papers maximize the groundwood content, but do not increase the number of breaks per roll of paper. Mechanical pulping processes have lower releases to the environment and use wood resources more efficiently than do bleached kraft pulping processes. Producing a ton of mechanical pulp requires about half the wood of a bleached kraft process. Mechanical pulping processes do, however, consume more purchased electricity than do bleached kraft pulping processes. The resulting emissions of air pollutants such as sulfur dioxide, nitrogen oxides and particulates depend on the fuels used by the utilities to generate this electricity. Figure C-2 and Table C-2 in Appendix C present a more detailed comparison of the environmental performance of coated freesheet and lightweight coated papers.

Improvements in the pulping and papermaking process have resulted in the manufacture of coated groundwood papers that have brightness similar to some coated freesheet grades. In some applications, coated groundwood papers can meet functional requirements at lower basis weights and at lower cost than coated freesheet papers.

- *Availability/timing*: The availability of No. 4 coated groundwood papers continues to grow. These papers have 77 to 80 GE brightness and other properties similar to the equivalent freesheet grade. Coated groundwood papers that will compete with No. 3 freesheet grades may become available in the near future. These papers generally have lower prices than coated freesheet paper with equivalent brightness.

Recommendation 6. Purchasers of printing and writing papers should express their preference for paper that substitutes bleached kraft for bleached sulfite pulps in cases where the paper meets functional and economic requirements.

- *Rationale:* On average, sulfite pulp mills in the United States have higher air and water emissions than bleached kraft pulp mills per ton of production. The size of releases, however, show more variability than do releases from bleached kraft mills, because sulfite mills use different pulping chemicals and technologies that depend on the mix of final products. Thus the performance of an individual sulfite mill may be similar to that of a kraft mill producing the same product. Because of this variability, purchasers who buy paper that contains sulfite pulp should evaluate the performance of the mill producing the paper. Figure C-3 and Table C-3 in Appendix C present a more detailed comparison of the environmental performance of business papers that contain bleached kraft and bleached sulfite pulps.

  Unbleached sulfite pulps are significantly brighter than unbleached kraft pulps. Sulfite pulps require lower quantities of bleaching chemicals and can achieve very high brightness levels as a result. High brightness, however, is appropriate only for highly specific uses. Sulfite pulps also are easier to bleach with TCF processes. While TCF bleaching will eliminate discharges of chlorinated organic compounds, purchasers should consider the overall environmental performance of mills that produce paper that contain sulfite pulps.

- *Availability/timing:* Most grades of printing and writing papers are produced with bleached kraft pulps; as a result, substitutes for sulfite pulps are widely available.

Recommendation 7. Purchasers of coated and uncoated freesheet paper should consider paper products that contain bleached chemithermomechanical pulp (BCTMP) as a partial substitute for hardwood kraft pulp in cases where the paper is available and meets functional and economic requirements.

- *Rationale:* BCTMP is the end product of a relatively new pulping process that offers paper manufacturers who need additional bleached pulp a high quality, lower-cost option that also has environmental advantages. The market price of BCTMP is about 12.5% lower than that of northern bleached hardwood kraft market pulp in mid-1995.[48] BCTMP costs less because the capital costs to install a new state-of-the-art mill are about half those of a new kraft mill per daily ton of capacity. BCTMP mills also can increase the amount of fiber available to papermakers. Their low water use, smaller efficient scale and low wood use compared to bleached kraft pulp mills allow these mills to be sited in locations where most kraft pulp mills cannot operate.

  BCTMP processes generate low releases to the environment and use wood resources efficiently compared to bleached kraft pulp. However, BCTMP processes consume more purchased energy. Thus, substituting BCTMP trades fossil fuels or hydropower for biomass fuels. Figure C-4 in Appendix C illustrates the effect on energy consumption and releases to the environment of incorporating 20% BCTMP into uncoated business paper.

  The impact on the recyclability of printing and writing papers that incorporate BCTMP depends on the grade of paper. The recyclability of coated papers is not affected by the addition of BCTMP, because “old magazines”, the grade of recovered paper that includes coated papers, already contains mechanically pulped fibers. The current recycling infrastructure can handle the gradual introduction of BCTMP in specialty uncoated papers produced by non-integrated mills. Bales of recovered paper with large quantities of BCTMP fiber will probably have less value than recovered paper with bleached kraft fibers.

- *Availability/timing*: Canadian mills produced about 2 million metric tons of BCTMP in 1994. They sell it primarily to European and Asian mills, where it is incorporated into a range of paper products. Paper mills in the northern United States with below-average energy costs have the most opportunity to use BCTMP, as the wood most suitable to BCTMP processes is grown there. These mills are also closer to the Canadian pulp mills that currently produce BCTMP; thus transportation costs should be lower for mills that buy market pulp. With the increase in hardwood bleached kraft pulp costs, some non-integrated paper mills in the United States have incorporated BCTMP into their paper. Traditional classifications of "freesheet" paper grades in the United States have limited the substitution of BCTMP for hardwood bleached kraft pulp to less than 10% of the fiber weight. Purchasing specifications based on groundwood/freesheet classifications may need to be reconsidered. Adjustments in the paper-recycling system may also be necessary.

Recommendation 8. Purchasers should be open to considering paper products that contain non-wood agricultural residue fiber in cases where the products are available and meet functional and economic requirements.

- *Rationale:* Opportunities to incorporate non-wood agricultural residue fiber into paper products may arise as a result of a combination of a mill's geographic location, specific product formulation and timing. Using agricultural residues in paper offers a beneficial use for what would otherwise be a waste product and does not entail additional use of land to provide fiber for use in paper.

  In contrast, currently available research suggests that, where there is a choice, it would be environmentally preferable to grow trees rather than annual crops for paper. These studies indicated that annual crops do not appear to offer a yield of fiber per acre per year significantly greater than that of fast-growing trees from plantations when one compares fibers with similar performance properties. In many cases, annual crops also may require higher and more frequent doses of fertilizer and pesticides to produce a ton of fiber than do tree plantations and do not provide additional benefits, including habitat for wildlife and water-quality protection.

  Modern papermaking with non-wood fibers, however, is in its infancy, and definitive information on the issues raised above is lacking. Non-wood fibers may also require smaller quantities of chemicals and consume less energy in chemical and mechanical pulp manufacturing processes. With additional research, new processes and technologies may be developed that enhance the environmental benefits of using annual crops as a source of fiber for papermaking, at least for specific paper grades of paper in specific regions of the United States.
- *Availability/timing*: A program in the Pacific Northwest to incorporate 7-10% rye straw into corrugating medium has been underway for several years. Other potential uses of non-wood fibers are in earlier stages of development. The Task Force's research suggests that non-wood pulps will have to overcome several economic barriers before they are widely used in paper products in the United States.

V. IMPLEMENTATION OPTIONS

The Paper Task Force has identified a range of action steps and guidance that purchasers can use to implement the recommendations on pulp and paper manufacturing. The first topic covered in this section is:

- *Action steps* — options that purchasers can use to increase their purchases of paper manufactured using environmentally preferable production processes

The remaining topics provide guidance for purchasers to use as they work with their suppliers to implement the recommendation concerning:

- *Minimum-impact mills* — a holistic manufacturing concept provided by paper suppliers that encompasses:
  - a vision and a definition of the minimum-impact mill
  - environmental management systems
  - manufacturing technology and R&D programs
- *Product reformulation* by changing the types of pulps used in paper products

All purchasers can select action steps that incorporate the Task Force's recommendations on pulp and paper manufacturing into their purchasing process. Purchasers' ability to communicate their interest in buying paper manufactured using environmentally preferable manufacturing processes depends on their position in the supply chain.

- Users of large quantities of paper who buy directly from inte-

grated paper mills can obtain information directly from their suppliers.
- Purchasers who buy from paper merchants and office products stores can ask them to obtain information from the paper manufacturer.
- Purchasers who buy paper from non-integrated manufacturers can ask the paper manufacturer to obtain information about the purchased pulps in their products.

Action Steps

1. Educate yourself about your paper use and your suppliers.

- Identify the key functional requirements of the paper based on its end uses. Informed purchasers can select paper based on its performance rather than by grade or classification. For example, a magazine publisher cares about the opacity, brightness, gloss, runability and printability of the paper. As long as the paper satisfies these requirements, the specific grade of paper is less important.
- Read publicly available information about your suppliers. Many paper manufacturers prepare annual environmental reports. These reports often provide descriptions of environmental management programs and compliance records. The more useful reports give quantitative measures of mills' energy use and releases to the environment. They explain what this data means and how it is changing over time. These reports can also discuss areas for improvement and future plans.

  Corporate annual reports and quarterly financial statements also contain useful information such as descriptions of major mill modernizations and other large investments. Quarterly financial statements often have information on a company's compliance record, because companies are required to report significant violations and fines to their shareholders. Be aware that standards and enforcement levels vary from state to state.

2. Have a dialogue with your supplier.

By including a discussion of environmental performance in a dialogue with suppliers, purchasers make their suppliers aware of the importance of this issue to them. The guidance below provides specific information that purchasers can ask for in discussions with their suppliers to broaden their understanding of their suppliers' commitment to continuous environmental improvement and of the progress they have made to date.

3. Develop a specification for a specific paper product.

Purchasers may wish to specify the types of pulps or a manufacturing process used in the paper they buy. These purchasers would then buy paper from the suppliers that meet the specification.

4. Reward suppliers with additional business.

Based on your evaluation and your supplier's ability to provide the paper products you want, purchasers may wish to purchase more paper from suppliers that meet their needs. Purchasers who take this step send a strong signal to the market about their interest in improved environmental performance.

5. Develop a strategic alliance with a supplier.

Developing a strategic alliance deepens the relationship with preferred suppliers. Purchasers generally buy larger quantities of paper within these alliances. Purchasers and suppliers also work together to achieve mutual long-term goals.

6. Work with your suppliers to establish goals and milestones for changing the paper you purchase.

Purchasers can work with suppliers to increase the percentage of their paper purchases that are made with specific process technologies over time, for example. Purchasers and suppliers may work together to reformulate a product by changing the types of pulps contained in that product.

Minimum-Impact Mills

In evaluating your suppliers' approach to the minimum-impact mill, obtain information from the suppliers on the following components:
- the vision and commitment to the minimum-impact mill
- the environmental management systems
- manufacturing technologies and research programs

Refer to Recommendations 1-3 for more information regarding these components. Use the quality and thoroughness of a supplier's answers to the questions below to assess the quality of their programs.

1. Vision and Commitment to the Minimum-Impact Mill

- A company-wide definition of the minimum-impact mill and a goal to progress toward it
- Plans to make process modifications or other pollution-prevention measures to make progress toward this goal
- How mills integrate the definition of the minimum-impact mill into their investment strategy, both for major new projects and for the replacement or renovation of individual pieces of equipment over time
  - Examples of investments in specific manufacturing technologies or systems that are consistent with achieving progress toward the minimum-impact mill
- How suppliers measure environmental progress at their mills

2. Environmental Management Systems

- Major features of the environmental management system (EMS)
- How mills measure the performance of the EMS
  - Examples of how the EMS has improved environmental performance
- Instances of "significant non-compliance" (a specific legal term) reported in the last 3 years
  - Plans to avoid these significant non-compliance events in the future
  - The role of the EMS in improving suppliers' compliance record
  - Future plans and past track record in going beyond regulatory compliance
- Once ISO 14001 is approved, would your suppliers consider obtaining certification for their mills?

3. Pulp and Paper Manufacturing Technologies and Research Programs

An assessment of manufacturing technologies provides the most direct information about suppliers' progress toward the minimum-impact mill. Suppliers' research and development programs indicate their commitment to continuous environmental improvement and their likelihood of installing advanced pollution-prevention technologies in advance of the average manufacturer.

Obtain the following information on pollution-prevention approaches to improve the manufacturing technologies for the paper you purchase that contains each of the following pulps:

Mechanical pulps:
- Reductions in the water and energy consumption

Unbleached pulps:
- Reductions in water consumption
- Reductions in the discharge of spent pulping liquor from spills and washing

Recycled content pulps:
- Reductions in water and energy consumption
- The bleaching process for deinked fiber
- Methods to reduce the landfilling of process residue (sludge)

Bleached kraft pulps:
- The pulping and bleaching processes used to produce the type of paper you purchase. [Evaluate their answer based on the diagram of technology pathways (Figure 9)]
- Plans for new manufacturing technology investments
  - Do these process technologies reduce natural resource consumption and releases to the environment?
  - If a supplier plans to install potential future technologies
    - What is their current level of development?
    - When do they expect to install these technologies at paper mills?

Obtain the following information on research and development programs:

- In-house research programs and/or support for research on advanced pollution-prevention technologies at schools of pulp and paper science
- Percentage of sales that funds these programs
- How have research programs translated into the development and installation of specific manufacturing technologies at suppliers' mills?

An assessment of manufacturing technologies provides the most direct information about suppliers' progress toward the minimum-impact mill.

Environmental Performance Indicators

Most businesses that seek to improve the quality of their products or services use quantitative measures to assess their progress. The Paper Task Force has developed two sets of measures that can be used to assess environmental progress toward the minimum-impact mill. The first set of indicators can be used to *evaluate one supplier's progress over time*. The second set can be used to *compare technologies used by different suppliers* to manufacture bleached kraft and sulfite pulp. These indicators are defined in the chapter's overview of pulp and paper manufacturing.

Using these indicators will not be a simple task initially, and will require a dialogue with your suppliers. At first, paper purchasers who have direct relationships with paper manufacturers will be most able to use these indicators. As more purchasers use this approach, it will become easier and more automatic.

Purchasers that buy paper from specific mills may prefer to receive these data on a mill-by-mill basis. Purchasers need data from individual mills to assess compliance records. Suppliers should be able to provide this information, because mills report these data to local and state regulators. Other purchasers may prefer to see these data on a more aggregated basis, at the division[49] or company level, for example. Aggregating these data may also avoid a supplier's concern about releasing proprietary information. Non-integrated manufacturers should be able to provide estimates of environmental releases that incorporate factors for the market pulp they buy.[50]

1. Indicators of General Environmental Performance

This set of indicators provides quantitative information about energy consumption and releases to the environment of regulated substances. Several inter-related factors affect the values of these indicators:

- The manufacturing technology at a mill
- The type of pollution-control equipment
- The operation of the pollution-control equipment
- Local environmental conditions
- Environmental permits (which are based on local environmental conditions and thus can vary among different states).

Local environmental conditions include the size of the river that the mill discharges into, the presence of other industrial facilities that also discharge into the river, or the number of people or sensitive ecosystems near the mill.

A list of the indicators, and how to collect and use them follows.

Indicators of General Environmental Performance

- *Biochemical Oxygen Demand (BOD)*
  Unit of Measure = kg/metric ton of final product
- *Color*
  Unit of Measure = kg/metric ton of final product
- *Fresh Water Use*
  Unit of Measure = gallons/ton of final product
- *Sulfur Dioxide (SO_2)*
  Unit of Measure = pounds/ton of final product
- *Nitrogen Oxides (NOx)*
  Unit of Measure = pounds/ton of final product
- *Total Reduced Sulfur Compounds (TRS)*
  Unit of Measure = pounds/ton of final product
- *Total Energy Consumption*
  Unit of Measure = millions of Btu's/ton of final product
- *Purchased Energy Consumption*
  Unit of Measure = millions of Btu's/ton of final product

Collecting the data:

- From suppliers, obtain state permit requirements, supplier emissions data and statistical process variability for the performance indicators above. Mills have these data because they monitor these indicators on a regular basis.
  - The *monthly average* describes the level of performance.
  - The *statistical variability of the data* describes the effectiveness of process control systems and the environmental management system.
  - Information can be requested for a *specific mill* or on a more aggregated level for a *division or company.*

Figure D-1 in Appendix D contains an example of a form developed by a Task Force member for its purchasers to collect these data.

Using the data:

- Compare the supplier-reported data to the state permit requirements to determine the following:
  - Is the supplier in compliance with environmental regulations?
  - Does the supplier's environmental performance go beyond compliance?

Purchasers should be aware that mills operate substantially below their permit limits on a routine basis.

- Compare data over several years to determine whether the supplier demonstrates continuous environmental improvement.
- Discuss suppliers' track record to understand the basis for their environmental performance. Ask about:
  - the technologies and other process changes the mill has made in the past to achieve their current level of performance
  - future plans to improve environmental performance
  - if improvements have been made in the past, discuss the current opportunities and limitations to achieving additional improvement
  - how the performance indicators measure the suppliers' progress and timing toward the long-term goal of the minimum-impact mill

2. Performance Indicators for Bleached Kraft and Sulfite Pulping Technologies

This set of performance indicators applies to mills that produce bleached kraft and sulfite pulp. Purchasers can use these indicators to *compare* the performance of pollution-prevention technologies and operations at different mills, because the size of the indicators depends on the technologies installed at the mill.

A list of the indicators, and how to collect and use them follows.

Indicators for Bleached Kraft and Sulfite Pulping Technologies

- *Bleach Plant Effluent Flow*
  Unit of Measure = gallons/ton of final product
- *Adsorbable Organic Halogens (AOX)*
  Unit of Measure = kg/metric ton of final product
- *Chemical Oxygen Demand (COD)*
  Unit of Measure = kg/metric ton of final product
- *Dioxins*
  Unit of Measure = picograms/liter of water (parts per quadrillion)

Collecting the data:

- From suppliers, obtain supplier emissions data and statistical process variability for the performance indicators above. Some states may include these parameters in their operating permits.
  - The *monthly average* describes the level of performance.
  - The *statistical variability of the data* describes the effectiveness of process control systems and the environmental management system.
  - Information can be requested for a *specific mill* or on a more aggregated level for a *division or company*.

Figure D-2 in Appendix D contains an example of a form developed by a Task Force member for its purchasers to collect these data.

Using these data:

- Compare the data reported by different manufacturers of the same product to assess the environmental performance of the pollution-prevention technologies installed by each supplier.
- Compare data over time to determine whether a supplier demonstrates continuous environmental improvement.
- Discuss these comparisons with suppliers to understand the basis for their environmental performance. Ask about:
  - the technologies and other process changes the mill has made to achieve this level of performance (For guidance, refer to the technology pathways in Figure 9.)
  - future plans to improve the level of performance
  - if improvements have been made in the past, discuss the current opportunities and limitations to achieving additional improvement
  - how the performance indicators measure the suppliers' progress and timing toward the long-term goal of the minimum-impact mill

Figure 10 illustrates trends in the size of these indicators for the bleach plant filtrates from a softwood bleached kraft pulp mill that uses a range of manufacturing technologies.

Product Reformulation Based on Changes in Pulps Used in Specific Paper Products

Many opportunities exist to substitute environmentally preferable pulps in paper products. Making these substitutions also may result in some cost savings for the purchaser. Purchasers must first evaluate their paper use to take advantage of these opportunities. To identify possible pulp substitutions, purchasers need to learn what types of pulp are used in a given paper product, and w the potential substitutes affect key functional requirenents. Table 2 lists major paper and paperboard grades, along with information about potential pulp substitutes.

Table 2

Potential Reformulation of Products Using Environmentally Preferable Pulps

PAPER GRADE (PULPS USED)	USES	POTENTIAL REFORMULATION OR SUBSTITUTION	AVAILABILITY/COMMENTS
Specialty Uncoated Freesheet (Bleached kraft pulp, some sulfite pulp)	Text and cover paper for books, letterhead, stationery, business cards, short printing runs (e.g.,invitations),etc.	Substitute bleached kraft for sulfite-based paper Substitute up to 30% BCTMP for hardwood bleached kraft pulp	Widely available except at very high brightness levels BCTMP market pulp is currently manufactured in Canada. Non-integrated suppliers are most likely to use it because BCTMP is less expensive than bleached kraft pulp
Coated Freesheet (Bleached kraft pulp)	Catalogs,higher-end magazines, direct mail inserts, annual reports, commercial printing	Substitute higher brightness papers containing mechanical pulp	Available; brightness levels are increasing to match some types of coated freesheet
Mottled White/ Solid Bleached Linerboard (Bleached kraft pulp)	Corrugated boxes	Unbleached linerboard	Widely available
Solid Bleached Sulfate Paperboard (Bleached kraft pulp)	Folding cartons and other packaging	Coated unbleached kraft paperboard	Availability is growing

VI. ANSWERS TO FREQUENTLY ASKED QUESTIONS

1. Why should purchasers be concerned with the environmental performance of a supplier beyond meeting federal, state and local regulations?

Being in compliance with environmental regulations is an important starting point but that may not be enough to help a supplier achieve the long-term goal of sustainable pulp and paper manufacturing or gain the additional environmental and economic advantages of pollution-prevention approaches in manufacturing.

Pulp and paper manufacturers already are making their production processes more sustainable by using pollution-prevention approaches. Some paper manufacturers view pollution as waste that results from an inefficient manufacturing process. Some have supported pollution-prevention approaches as providing an "extra margin of environmental safety," as a way to reduce the probability of undesired environmental surprises, or as a means of meeting future regulations and social expectations over the long lifespan of manufacturing equipment.

There are economic advantages to the pollution-prevention approach, as well. Some paper manufacturers have emphasized the competitive advantage that comes from more efficient use of resources, lower costs for complying with environmental regulations and the ability to compete more effectively in environmentally sensitive markets such as Europe.

By focusing on the process, companies have developed innovative technologies and practices that have reduced releases to the environment and saved money. Companies with strong pollution-reduction programs are moving forward for non-regulatory reasons. "We've gotten hooked on emissions reductions," says DuPont's vice president for safety, health and environment. "The lowest cost operators of the twenty-first century will be those with the least amount of environmental waste."[51]

2. Will implementing pollution-prevention approaches that reduce pulp mill releases to water result in larger releases to air or land?

Pollution-prevention approaches minimize releases of waste to the environment through technology changes, process control, raw material substitution, and product reformulation as well as through improved training, maintenance and housekeeping. These approaches seek to reduce pollution by avoiding its formation in the first place; therefore, pollution-prevention approaches do not include technologies or practices that transfer pollution across media. Sometimes, however, achieving a significant reduction in releases to water may result in a comparatively small increase in air emissions or solid waste. Pollution-prevention approaches reduce the total releases and risk to human health and the environment.

3. What is elemental chlorine-free (ECF) bleaching?

Elemental chlorine-free (ECF) bleaching processes substitute chlorine dioxide for elemental chlorine in the bleaching process.

Under some conditions, the use of chlorine dioxide in place of chlorine may not completely eliminate the presence of chlorine in the bleaching process, however. Chlorine can be formed in some older chlorine dioxide generating equipment, or can be created in chemical reactions involving chlorine dioxide in the bleach plant.

4. Are there different kinds of ECF bleaching processes?

The Task Force has identified three different processes: traditional ECF, enhanced ECF and low-effluent ECF processes.

- Mills with *traditional ECF* processes replace elemental chlorine with chlorine dioxide. Your suppliers may refer to this process as "ECF bleaching."
- Mills with *enhanced ECF* processes use oxygen delignification and/or extended delignification to remove more lignin during the pulping process before bleaching the pulp with an ECF process.
- Mills with *low-effluent ECF* processes have modified an enhanced ECF process to send additional organic waste generated in the bleach plant back to the chemical recovery system. In a low-effluent *ozone ECF* process, ozone replaces chlorine dioxide in the first bleaching stage of an enhanced ECF process. A second approach uses an enhanced ECF process but installs additional technologies in other parts of the mill to remove chlorides from the bleach plant filtrates. One such technology is undergoing a mill-scale demonstration in North Carolina.

5. Why should purchasers look for paper that contains bleached kraft pulp made with ECF bleaching processes?

- Eliminating elemental chlorine from the bleach plant reduces the environmental impacts associated with the discharge of highly-chlorinated organic compounds, such as dioxins.
- By installing improved pulping processes, such as oxygen delignification or extended delignification, mills can remove as much lignin as possible from the unbleached pulp, and thus reduce their chemical use and releases to the environment.
- Low-effluent processes reduce these releases further and thus provide additional progress to the long-term goal of the minimum-impact mill.

"The lowest cost operators of the 21st century will be those with the least amount of environmental waste."

6. Is the environmental performance of totally chlorine-free (TCF) bleaching processes better than that of ECF bleaching processes?

There is currently no simple answer to this question. It also depends on which pulping process one considers. When considering *TCF sulfite* pulps and *ECF kraft* pulps, purchasers should consider all releases to the environment rather than the discharge of chlorinated organic compounds alone. On average, mills that produce TCF sulfite pulps will have higher releases to air and water than do mills that produce ECF bleached kraft pulps. However, purchasers evaluating paper products that contain TCF sulfite pulps should compare the environmental performance indicators of these mills with the indicators from bleached kraft mills. The environmental performance of individual sulfite mills varies more than does that of individual bleached kraft pulp mills.

To date, most of the studies that compare the environmental effects of ECF and TCF effluents from bleached kraft mills have been performed at mills that have oxygen delignification and/or extended delignification. These studies have shown that the difference in the environmental impacts of the effluent from these processes is small; and the results of the studies have conflicted.

More research needs to be done to understand these differences.

Based on current research, TCF processes may provide the most efficient route to minimum bleach plant effluent flow by avoiding the generation of chlorides throughout the bleaching process. These technologies are described in the overview of Pulp and Paper Manufacturing. (See the next question for additional information.)

7. If dioxins are no longer detected in mill effluent, then hasn't the industry taken care of the problem?

The Science Advisory Board of the EPA recommends that dioxins be classified as a probable human carcinogen. Dioxin is also suspected of causing a range of neurological, reproductive and immune system disorders at very low levels of exposure. The current concentration of these persistent compounds in human tissues is approaching levels where one might start to see effects in certain human populations.[52] As a result of these concerns, current efforts focus on identifying and eliminating all sources of dioxins.

Dioxins were first discovered in bleached kraft and sulfite pulp manufacturing in 1985. Since then, the pulp and paper industry reports that it has reduced total emissions by 92%. Much of this progress has come from replacing elemental chlorine with chlorine dioxide.

Mills with ECF processes generally do not have detectable levels of dioxins in the final mill effluent. The fact that dioxins are not detected in mill effluent, however, does not mean that dioxins are never generated during the bleaching process. It simply means that the current tests are not sensitive enough to determine whether any dioxins are present. The only way mills can ensure that no dioxins are generated during the bleaching process is to eliminate the use of all chlorine compounds.

While eliminating all chlorine compounds from the bleach plant will prevent the generation of dioxins, dioxins are only one class of chemicals found in the releases from mills that produce bleached pulps. The Task Force recommends the minimum-impact mill approach because it encompasses a broader set of environmental issues that includes the elimination of dioxins. The next question examines why purchasers should consider these broader environmental concerns.

8. If dioxins are no longer detected in mill effluent, why do mills need to continue to reduce the quantity and improve the quality of their effluent?

While scientists have made great progress in understanding the effects of mill effluent on the environment, they still face considerable challenges to identifying all of the potential concerns. Scientists continue to find new substances in the complex mixture of organic material that is discharged in pulp mill effluent. It is unlikely that we will ever have a complete understanding of the toxic effects of the compounds in the effluent individually, let alone their effects as a mixture.

Field studies of the environmental effects of the effluent, while important, may not provide a complete picture of impacts. These biological and ecological studies are expensive and complex, and they often are highly limited in their ability to show specific cause-and-effect relationships.

Pollution-prevention approaches minimize the possibility of unwanted surprises by avoiding the release of these materials.

9. Is purchasing paper with lower brightness levels better for the environment?

Lowering brightness targets by up to 10 points is not likely to provide environmental benefits if the pulps used in the paper stay the same. Mills use relatively small amounts of chemicals to achieve the final pulp brightness, and some mills cannot economically reduce the brightness of the pulp or paper that they produce.

Lowering brightness standards does benefit the environment when it allows a papermaker to change the types of pulps used in the paper product. For example, lowering the brightness requirement of a coated publication paper from 83 to 78 GE brightness allows the publisher to use a high-quality coated groundwood paper in place of a coated freesheet. Maximizing the groundwood content in publication papers takes advantage of the fact that mechanical pulping processes have lower releases to the environment and use wood resources more efficiently than do bleached kraft pulping processes. In addition, coated groundwood paper generally costs less than does coated freesheet of equivalent quality.

Relaxing brightness requirements may also allow purchasers of packaging to switch from bleached to unbleached or recycled kraft paperboard. Purchasers who make this switch will buy an environmentally preferable paper product and will reduce costs.

Using paper with very high brightness levels will limit the opportunities to incorporate pulps made with environmentally preferable manufacturing processes.

10. Will adding mechanical pulps like bleached chemithermomechanical pulp (BCTMP) to business papers affect their recyclability?

Adding BCTMP to business papers will affect the recyclability of the paper, but the recycling collection infrastructure can adapt to its presence in paper products. In some cases, a bale of recovered paper with a large percentage of paper containing BCTMP (scrap from a printer, for example), would have a lower market value than a bale containing only kraft fibers.

BCTMP fibers themselves have greater recyclability because mechanically pulped fibers survive more recycling cycles than do chemically pulped fibers. Because modern deinking mills use hydrogen peroxide and other non-chlorine bleaching agents that brighten the pulp, incorporating BCTMP into office papers should not affect the quality of the resulting deinked pulp.

Mills that make tissue and newsprint from recovered paper already use recovered mechanical fiber, so the presence of BCTMP in the coated papers used in magazines and catalogs would not require change in the recycling infrastructure.

For manufacturers of deinked white pulp used in printing and writing paper, BCTMP will enter the recycling system gradually in the future, as non-integrated manufacturers of high-value printing and writing papers add this lower cost pulp to their paper. Deinking mills already allow a small percentage of groundwood in the recovered paper they purchase. These factors should allow the markets for recovered paper to adjust to the use of BCTMP in printing and writing papers in the United States.

11. Is paper that contains fiber made from non-wood annual crops environmentally preferable?

Of the non-wood fiber sources, the Task Force identified some environmental benefits associated with using agricultural residues, such as rye or wheat straw, in paper products. Incorporating pulps made from agricultural residues offers an additional local source of fiber for mills, and reduces the environmental impacts associated with disposing of this agricultural waste. Farmers formerly burned these residues, creating significant air pollution, until recent laws prohibited this practice in many regions.

The situation appears to be somewhat different for annual crops, such as kenaf. Where climatic and soil conditions allow one to choose between growing annual crops and trees, current research suggests that trees on this land would be preferable from an environmental perspective. These studies indicate that the fiber yields of non-wood plants do not appear to be significantly greater than those of fast-growing hardwood and softwood trees grown under intensive management regimes when one compares the yield of fibers with similar performance properties. Annual crops require higher and more frequent doses of fertilizer and pesticides to produce a ton of fiber than do tree plantations, and they do not provide additional benefits including habitat for wildlife and water quality protection.

Farmers who add an annual crop for paper to their crop rotations may see some benefits in reduced pesticide use and improved soil structure. However, farmers must weigh these benefits against the increased transportation costs to the pulp mill that may result from a more dispersed cultivation of the annual crops.

Generally, modern papermaking with non-wood fibers is in its infancy, and definitive information on the issues raised above is lacking. Non-wood fibers may also require smaller quantities of chemicals and consume less energy in chemical and mechanical pulp manufacturing processes. With additional research, new processes and technologies may be developed that enhance the environmental benefits of using annual crops as a source of fiber for papermaking, at least for specific grades of paper in specific regions of the United States. Purchasers should be open to considering papers made with fiber from annual crops where clear environmental benefits can be demonstrated.

12. Is it likely that major technologies are being developed that will fundamentally change pulping, bleaching or chemical recovery systems, but that these technologies are not widely known?

To date, because of the high cost of research and development, major technologies have been developed by paper manufacturers in concert with equipment suppliers. These major technologies generally are known and can be purchased by any company in the industry. It is unlikely that a paper supplier is *using* a major technology that provides substantial environmental benefits that is not known to others in the industry.

VII.APPENDICES

Appendix A. Ranges for Data on Environmental Parameters

Table A-1 contains ranges of several parameters for the bleach plant filtrates from softwood bleached kraft pulp mills with different manufacturing processes.

Table A-1

Ranges of Effluent Parameters for the Bleach Plant Filtrates from Softwood Bleached Kraft Pulp Mills

	Bleach plant effluent flow[53] (gallons per ton of air-dried pulp)	Biochemical Oxygen Demand (BOD) (kilograms per air-dried metric ton of pulp)	Color (kilograms per air-dried metric ton of pulp)	Adsorbable Organic Halogens (AOX) (kilograms per air-dried metric ton of pulp)	Chemical Oxygen Demand (COD) (kilograms per air-dried metric ton of pulp)
Traditional pulping and bleaching (50% chlorine dioxide substitution in the first bleaching stage)	12,000	10.9 - 15.5*[54] 54	86.5 - 127*[54] 54	1.8 - 2.2[55] 57	65[56] 57
Traditional ECF	12,000	14.5 - 15.1*[55]	71.5 - 113*[55]	1.5[58]	65[58]
Enhanced ECF	5,000 - 7,500	6.0 - 11[57]	40 - 72[57]	0.40 - 1.1[58]	25 - 45[59]
Low effluent ozone ECF	1,300 - 3,800	4.4[60]	3.1[60]	0.1[60]	11[60]
Low effluent TCF	1,300 - 3,800	2.9[61]	4.2[61]	background levels [61]	8.9[61]
Enhanced ECF with chloride removal	1,300 - 3,800	2.0[62]	2.0[62]	0.1 [62]	8 - 11[63]

* Not statistically different

Appendix B. Cost Model for Bleached Kraft Pulp Manufacturing Technologies

This appendix presents additional information on the cost model developed for installing pollution-prevention technologies at bleached kraft pulp mills. White Paper No. 7 provides a full discussion of this model. The model has two parts:

- Capital cost scenarios based on mill-specific factors
- A detailed estimate of capital and operating costs for three model mills based on a mid-range capital cost scenario

Capital Cost Scenarios

A series of capital cost scenarios for bleached kraft pulp mills in different configurations follows. These scenarios represent the highest to lowest costs to install currently available pollution- prevention technologies, such as oxygen delignification, at bleached kraft pulp mills.

- *Mills that produce more pulp than they use and have limited recovery boiler capacity, space, equipment, or other limitations*
  The next major investment at these mills generally balances pulp and final product production by adding another paper machine at the mill.
- *Existing mills with limited recovery boiler capacity*
  Installing enhanced ECF or low-effluent processes requires a major upgrade to the recovery boiler and might require a replacement. Recovery capacity limitations can add from $20 to $75 million to the capital costs of these technology options.
- *Existing mills with space or equipment limitations*
  These mills have available recovery boiler capacity, but must

install additional equipment to operate an enhanced ECF or low effluent process. These limitations are highly site-specific and depend on the age and configuration of the mill. A mill may need to replace inefficient unbleached pulp washing systems rather than upgrade them. Space limitations may also require a new building for the oxygen delignification system.

- *Mills with incremental recovery boiler capacity available and no site-specific or equipment limitations*
  The Paper Task Force cost model in White Paper No. 7 used this scenario as a base case. As suggested by this list, individual mills may face costs that are higher or lower than those analyzed in the model. However, the model does provide a good basis for the comparison of different technologies and the sensitivity of costs to other internal or external factors.
- *The mill must install new equipment to upgrade to a traditional ECF process*
  In some cases, in order to eliminate elemental chlorine from the bleach plant under a traditional ECF approach, the mill must install new equipment. This new equipment can make the traditional ECF approach more expensive than enhanced ECF pulping and bleaching. For example, a mill may have to install new chlorine dioxide generators in order to eliminate its use of elemental chlorine, rather than upgrading its existing generators. Thus, the basis for the comparison has changed, because of the age and configuration of the mill's bleaching system.
- *Installing enhanced ECF or low-effluent processes allows a mill to increase capacity by debottlenecking other processes*
  Installing oxygen delignification and low-effluent processes may allow a mill to obtain a small capacity increase (on the order of 5% - 10%) without increasing the size of the effluent treatment, air emission controls or other systems at the mill. The revenue earned by increasing the production of pulp or paper improves the economics. For example, if a 1000 metric ton per day market pulp mill can increase its capacity by 50 tons per day, the mill saves $20,000 per day (assuming a $400 difference in internal pulp production costs and the price of market pulp.)
- *Increase capacity during a major modernization at a mill*
  Recovery boilers, digesters, bleach lines and other large components of a bleached kraft pulp mill need to be replaced or renovated every 15 to 20 years. Installing technologies that reduce chlorine dioxide use and the organic loading in the effluent allow the company to avoid investments in additional chlorine dioxide generators and larger air emissions control and effluent treatment systems.

  Mills faced with a major investment in equipment often increase capacity (1) to get additional revenue to offset the $300 to $500 million capital investment and (2) to increase their production of low cost, high quality pulp. In some cases, modernizations include paper machines to use this pulp; in other cases, companies reduce production at higher cost mills to lower manufacturing costs systemwide.
- *Building a greenfield (completely new) mill*
  Mills install a combination of technologies that result in the lowest capital and operating costs. Low-effluent ozone ECF and TCF systems have the best economics because they have the lowest operating costs and avoid the investment in chlorine dioxide generators and large effluent treatment systems.

Detailed Cost Model

The Task Force developed capital and operating cost estimates to install pollution-prevention technologies at existing mills with traditional pulping and 50% chlorine dioxide substitution for elemental chlorine in the first bleaching stage. The pollution–prevention technologies included:

- traditional ECF
- ECF with oxygen delignification or extended delignification (enhanced ECF)
- low-effluent ozone ECF, both medium (MC) and (HC) high consistency
- low-effluent ozone TCF
- enhanced ECF with chloride removal

We considered the costs to install these technologies at three model bleached kraft mills which varied by capacity and wood species used.

- Mill 1 produces 1000 air-dried metric tons per day (ADMT/D) of softwood bleached kraft pulp
- Mill 2 produces 500 air-dried metric tons per day (ADMT/D) of softwood bleached kraft pulp

Table B-1

Annualized After-Tax Per-Ton Total Costs

Technology option	Capital costs (millions of dollars)	Annualized capital costs ($/ADMT)	Incremental operating costs ($/ADMT)	Total cost year 1 ($/ADMT)
Mill 1 (1000 ADMT/D softwood)				
Base case	$0.0	$0.00	$0.00	$0.00
Traditional ECF	$28.9	$8.97	$8.72	$17.69
Enhanced ECF	$35.8	$11.13	($2.38)	$8.76
MC Ozone ECF	$40.8	$12.67	($1.30)	$11.37
HC Ozone ECF	$50.8	$15.80	($1.74)	$14.06
MC Ozone TCF	$42.8	$13.29	$8.08	$21.37
HC Ozone TCF	$52.8	$16.40	($2.23)	$14.17
Enhanced ECF + chloride removal	$55.8	$17.35	$3.56	$20.91
Mill 2 (500 ADMT/D softwood)				
Base case	$0.0	$0.00	$0.00	$0.00
Traditional ECF	$18.0	$12.36	$8.72	$21.08
Enhanced ECF	$25.1	$17.25	($1.97)	$15.08
MC Ozone ECF	$29.3	$20.10	($0.71)	$19.40
HC Ozone ECF	$35.0	$24.04	($1.06)	$22.98
MC Ozone TCF	$30.6	$21.01	$8.71	$29.72
HC Ozone TCF	$36.3	$24.95	($1.51)	$23.43
Enhanced ECF + chloride removal	$38.3	$26.31	$3.97	$30.28
Mill 3 (500 ADMT/D hardwood				
Base case	$0.0	$0.00	$0.00	$0.00
Traditional ECF	$16.8	$11.50	$6.41	$20.22
Enhanced ECF	$25.1	$17.25	$1.75	$19.00
MC Ozone ECF	$29.3	$20.10	$3.50	$23.60
HC Ozone ECF	$35.0	$24.04	$5.74	$29.79
HC Ozone TCF	$36.3	$24.95	$3.99	$28.63
Enhanced ECF + chloride removal	$38.3	$26.31	$7.69	$34.00

Tax rate 34%

- Mill 3 produces 500 air-dried metric tons per day (ADMT/D) of hardwood bleached kraft pulp

Table B-1 presents the capital, operating and incremental costs associated with installing a range of pollution-prevention technologies at the existing model mills. All costs are presented on an after-tax basis using the standard federal corporate tax rate of 34%. Capital costs were annualized using an equipment life of 15 years and a cost of capital and debt of 10%. The annualized capital costs also include the tax savings that result from straight-line depreciation of the capital costs. Operating costs include chemical costs, power costs and additional technical and maintenance support for new equipment.

This cost model indicates that the traditional ECF processes have the highest operating costs for all three model mills, while enhanced ECF and ozone TCF processes have the lowest operating costs. The difference in the total costs associated with installing any of the pollution-prevention technologies at the base case mills is about $15 per air-dried metric ton of pulp.

Appendix C. Environmental Comparison for Different Paper Products

This appendix presents additional information on the environmental comparisons of paper products that contain different pulps. We present comparisons of energy consumption and releases to air, water and land for the products discussed in Recommendations 4 - 7. The paper products discussed in this appendix are:

- *Coated paperboard:* Solid bleached sulfate and coated unbleached kraft paperboard (Recommendation 4, White Paper 10C)
- *Coated publication papers:* Coated freesheet and lightweight coated groundwood pulps (Recommendation 5, White Paper No. 10A)
- *Business papers:* Bleached kraft and sulfite pulps (Recommendation 6, White Paper No. 12)
- *Business papers:* Bleached kraft pulp and bleached kraft pulp with 20% bleached chemithermomechanical pulp (BCTMP) (Recommendation 7, White Paper No. 12)

The energy consumption data includes the energy consumed to produce the bleaching chemicals along with the energy required in the paper manufacturing process. In the charts, we use a weighted average of three bleached kraft pulping processes in the calculation of the environmental parameters. The weighted average is based on the 1994 U.S. production of the following types of bleached kraft pulp:

- Traditional pulping and bleaching – 50% chlorine dioxide and 50% elemental chlorine in the first bleaching stage (50% D)
- Traditional ECF (100% D)
- Enhanced ECF using oxygen delignification (O + 100% D)

Coated Paperboard

Coated paperboard generally contains 84%-85% fiber, 9%-10% coating and 6% moisture. Figure C-1 and Table C-1 present the average and ranges of energy consumption and environmental parameters for solid bleached sulfate (SBS) paperboard that contains bleached kraft pulp and coated unbleached kraft (CUK) paperboard that contains unbleached kraft pulp.

With the exception of emissions of hazardous air pollutants, the energy consumption and environmental releases generated during the production of SBS are higher than those of CUK. The higher hazardous air pollutant emissions generated during CUK production are thought to result from a carryover of organic material from the pulping process. These results illustrate the change in environmental performance that results from bleaching kraft pulp.

Coated Publication Papers

Coated printing and writing papers generally contain about 30% coating by weight. Coated freesheet (CFS) paper contains approximately 64% bleached kraft hardwood and softwood pulps; lightweight coated groundwood (LWC) papers usually contain a 50:50 mix of bleached softwood kraft pulp and groundwood pulp. Figure C-2 and Table C-2 present the average and the ranges, respectively, for energy consumption and releases to the environment generated during the production of these grades of paper.

Figure C-2 illustrates the effect of high-yield pulping processes on energy consumption and releases to the environment. The purchased energy is higher for the lightweight coated groundwood paper because little wood waste is available as fuel. Emissions of sulfur dioxide, nitrogen oxides and carbon dioxide from burning fossil fuels generally depend on the amount of purchased electricity, which is high for groundwood pulping processes. Process-related air emissions and releases to water are lower for LWC than they are for coated freesheet, because the higher-yield groundwood process converts more wood into pulp than does the kraft process.

Business Papers with Bleached Kraft and Sulfite Pulps

Uncoated business papers made with an alkaline process generally contain 78% bleached pulp, 16% calcium carbonate filler and 6% water. Figure C-3 and Table C-3 present a comparison of the energy consumption and releases to the environment generated by business papers that contain bleached kraft pulp and bleached sulfite pulps.

Bleached sulfite pulping processes consume less total and purchased energy than do bleached kraft pulping processes because smaller quantities of chemicals are used to bleach sulfite pulps. In this case, the sulfite is bleached with a combination of elemental chlorine and sodium hypochlorite, a process that is currently used by several sulfite mills in the U.S. Releases of particulates and carbon dioxide reflect the lower energy consumption of the sulfite process.

Sulfur dioxide and nitrogen oxide emissions generated during the production of paper that contains sulfite pulp are generally higher than those generated during the production of paper that contains bleached kraft pulp. Some sulfite mills release these pollutants from process sources. With the exception of total suspended solids, releases to water are higher, on average, for paper that contains sulfite pulp. Table C-3 presents the ranges for business paper that contains bleached kraft and bleached sulfite pulps. The ranges for the sulfite paper are generally larger than are those for the kraft paper. Sulfite mills choose from a wider range of pulping chemicals and process conditions than do bleached kraft pulp mills. Thus, the releases to the environment from sulfite mills will vary depending on the manufacturing process and on the products made at the mill.

Business Papers with Bleached Kraft Pulp and BCTMP

In this case, we compare a business paper that contains bleached kraft pulp with one in which BCTMP replaces 20% of the hardwood bleached kraft pulp. High-brightness BCTMP adds bulk, stiffness and opacity to paper, without compromising functional performance. Uncoated business paper with 20-30% hardwood BCTMP has similar functional performance to the bleached kraft product. Figure C-4 and Table C-3 present a comparison of the energy consumption and releases to the environment generated by business papers that contain bleached kraft pulp and bleached kraft pulp with 20% BCTMP.

Figure C-4 illustrates that substituting 20% BCTMP for hardwood bleached kraft pulp results in changes in energy consumption and releases to the environment that are similar to those seen in the comparison of coated papers above. Purchased energy, sulfur dioxide, nitrogen oxides and carbon dioxide from fossil fuels increase when BCTMP replaces hardwood kraft. Process-related air emissions, effluent flow and releases to water decline.

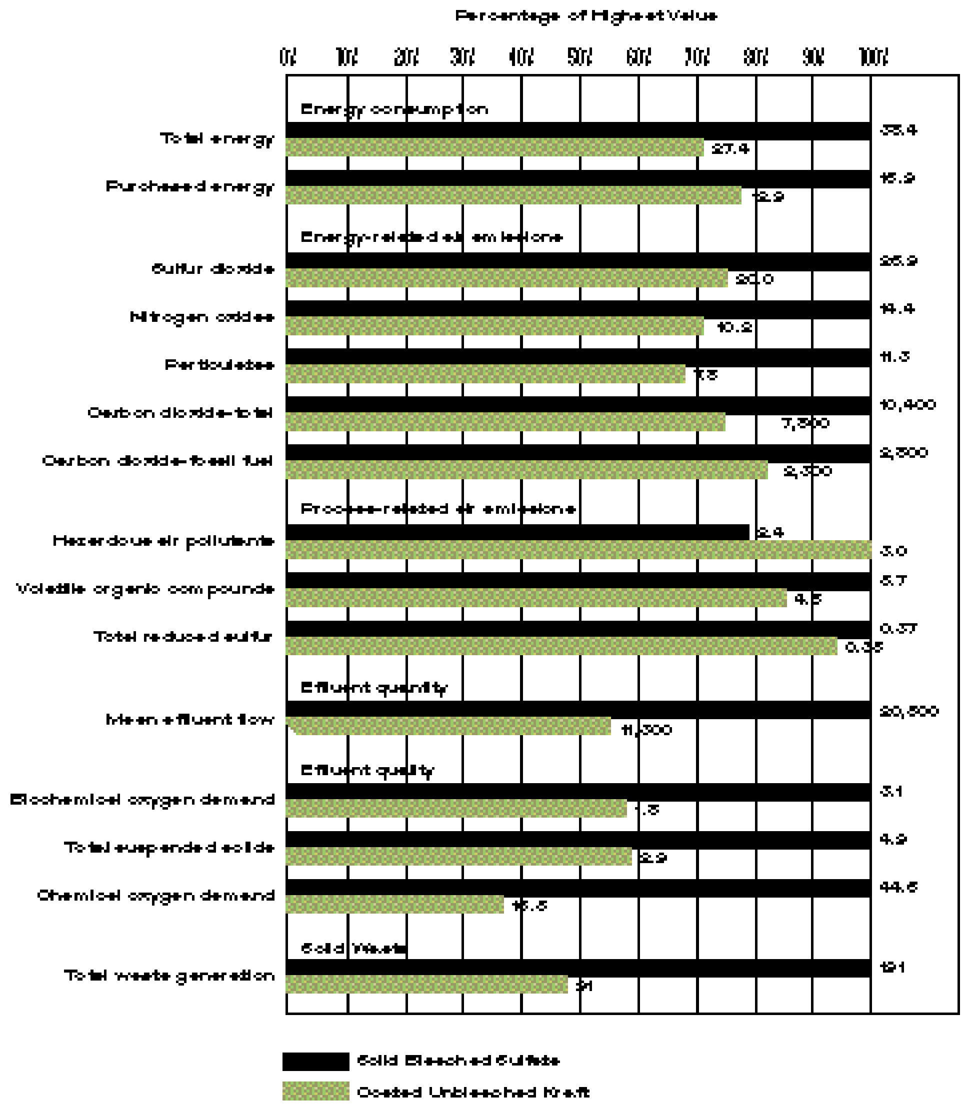
The releases associated with the BCTMP process also depend on the age of the mill and the fuels used to produce electricity for the pulping process. Two new Canadian BCTMP market pulp mills operate in an effluent-free mode. These mills also use hydropower to generate electricity. Thus, energy-related air emissions for paper that contains BCTMP from these mills would be smaller than those shown in Figure C-4. Using hydropower, however, results in other impacts on the environment. The releases of sulfur dioxide, nitrogen oxides, particulates and carbon dioxide in all four comparisons assume that the mill purchases electricity from a utility that uses the national fuel mix of the United States. This fuel mix contains mostly oil and coal.

Appendix D. Examples of Evaluation Forms for Environmental Performance Indicators

A Task Force member has designed forms for its purchasers to use to collect data on the environmental performance indicators. Figures D-1 and D-2 contain these forms for the indicators of general environmental performance and the performance indicators for bleached kraft and sulfite mills, respectively.

Figure C-1

Average Environmental Parameters for Coated Paperboard



Note: Energy consumption: millions of BTUs per air-dried ton of product
Air emissions: pounds per air-dried ton of final product
Effluent flow: gallons per air-dried ton of final product
Effluent quality and solid waste: kilograms per air-dried metric ton of final product

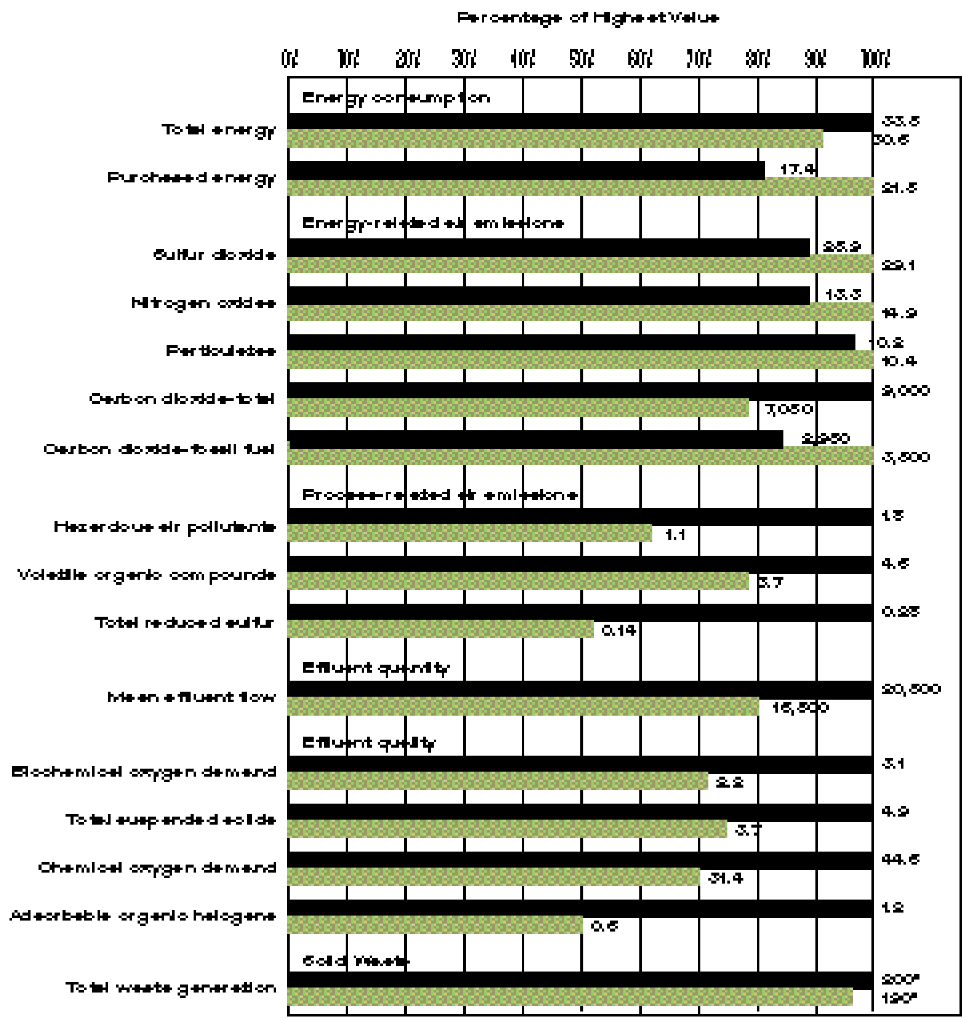
Table C-1

Environmental Parameters for Coated Paperboard

ENVIRONMENTAL PARAMETERS	SOLID BLEACHED SULFATE				COATED UNBLEACHED KRAFT
	50% D	100% D	0+100% D	AVERAGE	
Energy Usage (millions of Btu's per air-dried ton of product)					
Total	37.8 -39.3	40.0 -41.6	35.4 -37.0	37.6 -39.2	26.6 -28.2
Purchased	13.6 -21.2	15.8 -23.4	9.6 -17.2	13.1 -20.7	10.0 -15.8
ENERGY-RELATED AIR EMISSIONS (pounds per air-dried ton of product)					
Sulfur dioxide (SO_2)	23.3 -31.5	26.1 -34.3	18.8 -27.0	22.8 -31.0	16.8 -23.2
Nitrogen oxides (NO_x)	13.2 -16.0	14.6 -17.4	11.1 -13.9	13.0 -15.8	9.1 -11.3
Particulates	10.4 -12.2	11.5 -13.1	9.4 -11.3	10.4 -12.1	7.7 -7.8
Carbon dioxide (CO_2) - total	9,600 -11,200	9,800 -11,500	9,400 -11,100	9,400 -11,200	7,400 -8,000
Carbon dioxide (CO_2) - fossil fuel	2,300 -3,700	2,600 -4,000	1,600 -3,000	2,200 -3,600	1,900 -2,900
PROCESS-RELATED AIR EMISSIONS (pounds per air-dried ton of product)					
Hazardous air pollutants (HAP)	2.4	2.0	2.3 - 2.9	2.4	3.0
Volatile organic compounds (VOC)	5.7	5.7	5.4 - 5.8	5.7	4.8
Total reduced sulfur (TRS)	0.37	0.37	0.36	0.37	0.35
EFFLUENT QUANTITY (gallons per air-dried ton of final product)					
Mean effluent flow	22,000	22,000	14,700	20,500	11,300
EFFLUENT QUALITY (kilograms per air-dried metric ton of final product)					
Biochemical oxygen demand (BOD)	0.3 - 6.7	0.3 - 6.7	0.3 - 6.7	0.3 - 6.7	0.2 - 2.8
Total suspended solids (TSS)	0.2 - 9.8	0.2 - 9.8	0.2 - 9.8	0.2 - 9.8	0.7 - 6.1
Chemical oxygen demand (COD)	15.8 - 79.5	15.8 - 79.5	15.8 - 79.5	15.8 - 79.5	5.1 - 24.2
SOLID WASTE (kilograms per air-dried metric ton of final product)					
Total waste generation	191	191	191	191	91

Figure C-2

Average Environmental Parameters for Coated Publication Papers



Coated free-sheet

Lightweight coated groundwood

Note: Energy consumption: millions of BTUs per air-dried ton of product
Air emissions: pounds per air-dried ton of final product
Effluent flow: gallons per air-dried ton of final product
Effluent quality and solid waste: kilograms per air-dried metric ton of final product
*Not statistically different

Table C-2

Environmental Parameters for Coated Publication Papers

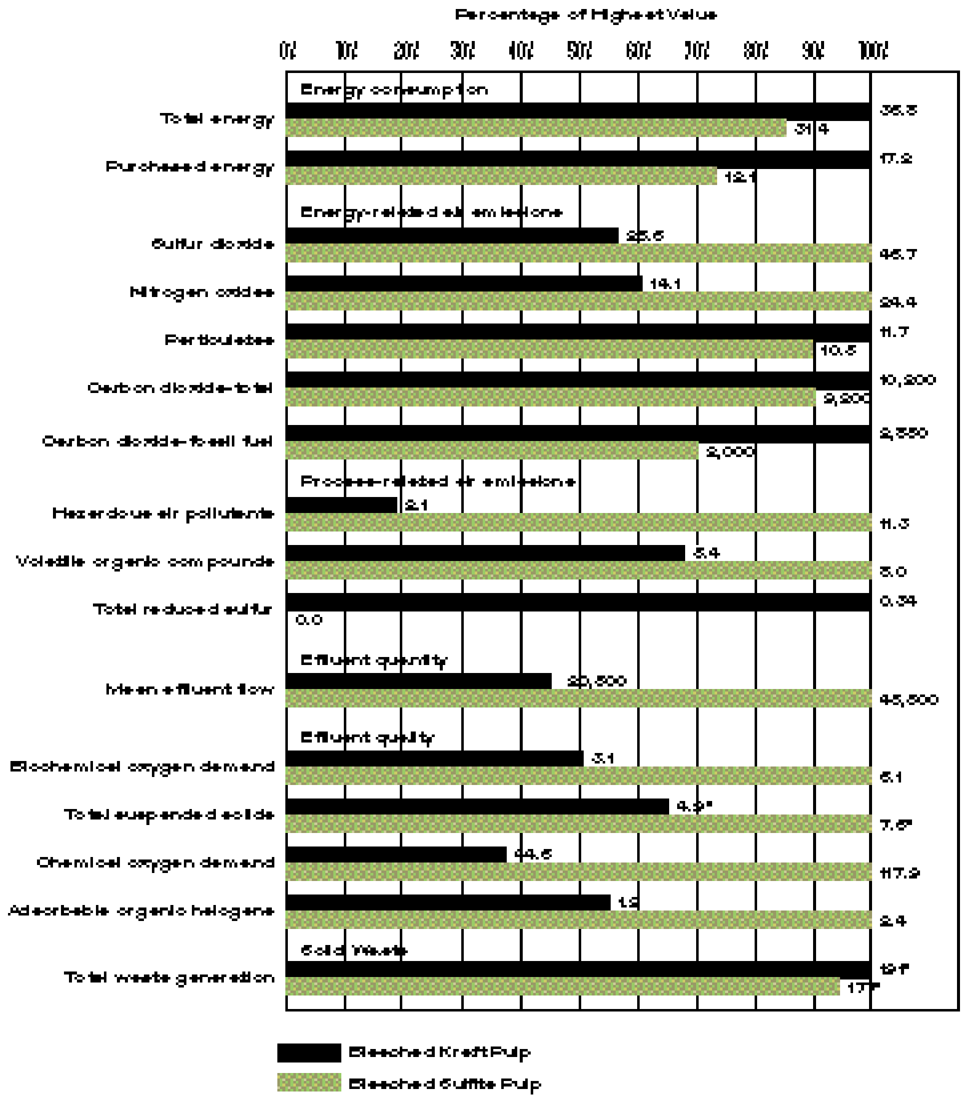
ENVIRONMENTAL PARAMETERS	COATED FREE SHEET				
	50% D	100% D	0+100% D	AVERAGE	LIGHTWEIGHT COATED GROUNDWOOD
Energy Usage (millions of Btus/per air-dried ton of product)					
Total	32.8 - 34.3	34.6 - 36.1	31.0 - 32.5	32.8 - 34.3	30.2 - 31.0
Purchased	14.6 - 20.6	16.4 - 22.5	11.4 - 17.4	14.4 - 20.4	19.9 - 23.0
ENERGY-RELATED AIR EMISSIONS (pounds per air-dried ton of product)					
Sulfur dioxide (SO_2)	23.0 - 29.6	25.3 - 31.9	19.4 - 26.0	22.6 - 29.1	27.5 - 30.8
Nitrogen oxides (NO_x)	12.3 - 14.6	13.5 - 15.8	10.7 - 12.9	12.2 - 14.4	14.3 - 15.5
Particulates	10.3	11.1	9.6	10.3	10.4
Carbon dioxide (CO_2) - total	8,700 - 9,300	9,000 - 9,600	8,700 - 9,300	8,700 - 9,300	6,900 - 7,200
Carbon dioxide (CO_2) - fossil fuel	2,500 - 3,600	2,800 - 3,900	1,900 - 3,100	2,400 - 3,500	3,200 - 3,800
PROCESS-RELATED AIR EMISSIONS (pounds per air-dried ton of product)					
Hazardous air pollutants (HAP)	1.8	1.5	1.7 - 2.2	1.8	1.1
Volatile organic compounds (VOC)	4.6	4.6	4.3 - 4.7	4.7	3.7
Total reduced sulfur (TRS)	0.28	0.28	0.27	0.28	0.14
EFFLUENT QUANTITY (gallons per air-dried ton of final product)					
Mean effluent flow	22,000	22,000	14,700	20,500	16,500
EFFLUENT QUALITY (kilograms per air-dried metric ton of final product)					
Biochemical oxygen demand (BOD)	0.3 - 6.7	0.3 - 6.7	0.3 - 6.7	0.3 - 6.7	0.2 - 5.1
Total suspended solids (TSS)	0.2 - 9.8	0.2 - 9.8	0.2 - 9.8	0.2 - 9.8	0.4 - 8.2
Chemical oxygen demand (COD)	15.8 - 79.5	15.8 - 79.5	15.8 - 79.5	15.8 - 79.5	9.6 - 56.3
Adsorbable organic halogens (AOX)	1.5 - 1.8	0.6	0.1 - 0.2	1.1 - 1.3	0.6 - 0.7
SOLID WASTE (kilograms per air dried metric ton of final product)					
Total waste generation	200*	200*	200*	200*	190*

Note:

* Not statistically different

Figure C-3

Average Environmental Parameters for Business Papers with Bleached Kraft and Bleached Sulfite Pulps



Note: Energy consumption: millions of Btu's per air-dried ton of product
Air emissions: pounds per air-dried ton of final product
Effluent flow: gallons per air-dried ton of final product
Effluent quality and solid waste: kilograms per air-dried metric ton of final product
*Not statistically different

Table C-3

Environmental Parameters for Business Papers

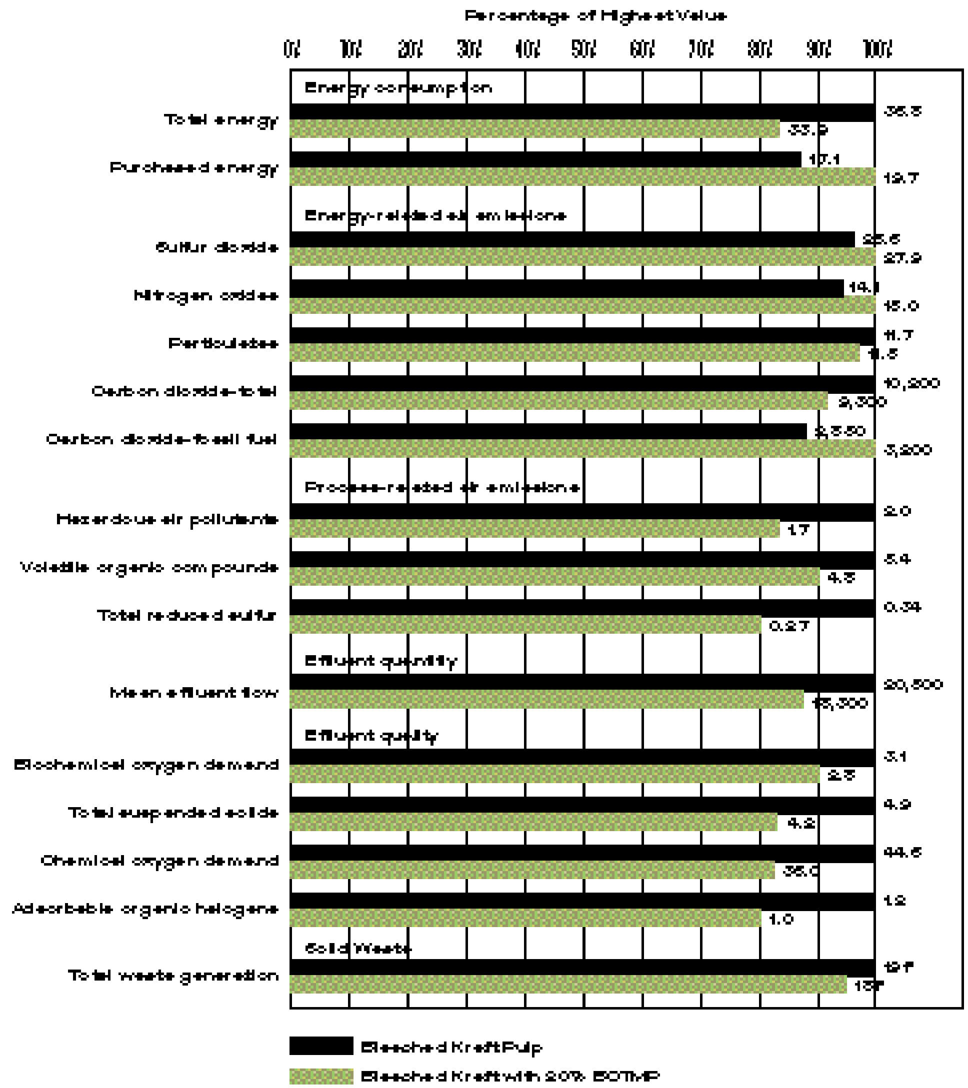
ENVIRONMENTAL PARAMETERS	BLEACHED KRAFT PULP				BLEACHED SULFITE PULP	BLEACHED KRAFT PULP WITH 20% BCTMP
	50% D	100% D	0 + 100% D	AVERAGE		
Energy Usage (millions of Btu per air-dried to of product)						
Total	36.2 - 37.7	38.2 -39.7	34.1 -35.5	36.0 -37.5	31.4	31.4 - 36.4
Purchased	14.1 - 21.0	16.1 -23.1	10.4 -17.3	13.6 -20.6	12.1	16.9 - 22.5
ENERGY-RELATED AIR EMISSIONS (pounds per air dried ton of product)						
Sulfur dioxide (SO_2)	23.4 -30.9	25.9 - 33.4	19.2 - 26.7	22.9 -30.4	20.9 - 72.6	24.9 - 31.0
Nitrogen oxides (NO_x)	13.1 - 15.6	14.4 - 16.9	11.1 -13.7	12.9 -37.4	11.4 - 37.4	13.9 - 16.0
Particulates	11.7	12.6	11.0	11.7	10.5	11.4 - 11.5
Carbon dioxide (CO_2) - total	9,700 - 10,500	10,100 - 10,900	9,700 -10,500	9,800 - 10,600	9,200	9,000 -9,600
Carbon dioxide (CO_2) - fossil fuel	2,300 -3,700	2,600 - 3,900	1,600 -2,900	2,200 -3,500	2,000	2,700 -3,700
PROCESS-RELATED AIR EMISSIONS (pounds per air-dried ton of product)						
Hazardous air pollutants (HAP)	2.0	1.7	2.6	2.1	11.3	1.7
Volatile organic compounds (VOC)	5.3	5.4	5.5	5.4	8.0	4.8
Total reduced sulfur (TRS)	0.3	0.3	0.3	0.3	0.0	0.3
EFFLUENT QUANTITY (gallons per air-dried ton of final product)						
Mean effluent flow	22,000	22,000	14,700	20,500	45,500	18,300
EFFLUENT QUALITY (kilograms per air-dried metric ton of final product)						
Biochemical oxygen demand (BOD)	0.3 - 6.7	0.3 - 6.7	0.3 - 6.7	0.3 - 6.7	0.3-6.7	2.8
Total suspended solids (TSS)	0.2 - 9.8*	0.2 - 9.8*	0.2 - 9.8*	0.2 - 9.8*	0.4-10.7*	4.2
Chemical oxygen demand (COD)	15.8 - 79.5	15.8 - 79.5	15.8 - 79.5	15.8 - 79.5	63.7-200	36.0
Adsorbable organic halogens (AOX)	1.6 - 1.8	0.6	0.1 - 0.2	1.1 - 1.3	0 - 5.2	0.9 - 1.0
SOLID WASTE (kilograms per air-dried metric ton of final product)						
Total waste generation	191*	191*	191*	191*	177*	181*

Note:

* Not statistically different

Figure C-4

Average Environmental Parameters for Business Papers with Bleached Kraft Pulp and BCTMP



Note: Energy consumption: millions of Btu's per air-dried ton of product
Air emissions: pounds per air-dried ton of final product
Effluent flow: gallons per air-dried ton of final product
Effluent quality and solid waste: kilograms per air-dried metric ton of final product
*Not statistically different

Table D-1

Indicators of General Environmental Performance

HOW TO OBTAIN DATA:

- From supplier, obtain state permit requirements, supplier emissions data, and statistical process variability for the parameters below. Mills have this data, as they monitor these parameters on an on-going basis.

HOW TO USE DATA:

- Compare supplier reported data to state permit requirements to determine the following:
  1. Is supplier in compliance with environmental regulations?
  2. Does supplier's environmental performance go beyond compliance?
- Compare on-going annual data to determine whether supplier is demonstrating continuous environmental improvement. *(Improvements that have been made in the past should be considered, as well as current information, and plans for the future.)*
- Discuss with supplier the following:
  1. The technologies and other process changes the mill has made to achieve this level of performance.
  2. Their future plans to improve upon current level of performance and the desired impact.

Values for these indicators reflect: manufacturing technology used by mill type and effectiveness of pollution-control equipment	Supplier State Permit Levels	1994 Supplier Annual Monthly Average	1994 Supplier Process Variability (Percentage)	1995 Supplier Annual Monthly Average	1995 Supplier Process Variability (Percentage)	1996 Supplier Annual Monthly Average	1996 Supplier Process Variability (Percentage)
Biochemical Oxygen Demand (BOD) Unit of measure = kg/metric ton of product							
Color Unit of measure = kg/metric ton of product							
Fresh Water Use Unit of measure = gallons/ton of product							
Sulfur Dioxide (SO_2) Unit of measure = pounds/ton of final product.							
Nitrogen Oxides (NO_X) Unit of measure = pounds/ton of final product							
Total Reduced Sulfur Compounds (TRS) Unit of measure = pounds/ton of final product							
Total Energy Consumption Unit of measure = millions of Btu's/ton of final product							
Purchased Energy Consumption Unit of measure = millions of Btu's/ton of final product							

All data should be provided on a per ton of product manufactured basis.

The monthly average provides information about the mill's level of performance. As mills implement pollution-prevention technologies, the magnitude of the performance indicators should decrease.

The variability provides some information about the mill's ability to control the manufacturing process. Improved process control, maintenance and housekeeping should reduce the variability of these indicators over time.

Information can be provided on a *specific mill basis* or on an *aggregated basis at the division or company level.*

Table D-2

Performance Indicators for Bleached Kraft and Sulfite Pulps

HOW TO OBTAIN DATA:

- From supplier, obtain state permit requirements, supplier emissions data, and statistical process variability for the parameters below. Mills have this data, as they monitor these parameters on an on-going basis.

HOW TO USE DATA:

- Discuss with supplier the following:
  1. The bleaching technologies employed to achieve this level of performance. (For guidance, refer to technology pathway presented in Recommendation 3.)
  2. Their future plans to improve on their current level of performance.
- Compare the data reported by all manufacturers of the same product category to compare the environmental performance of the pollution-prevention technologies installed by each supplier.
- Compare on-going annual data to determine whether supplier is demonstrating continuous environmental improvement. *(Improvements that have been made in the past should be considered, as well as current information, and plans for the future.)*

Values for these indicators reflect: • **The performance of pollution-prevention technologies and operations employed by a mill, (the magnitude of the indicators depends on the technologies installed at the mill).** • **Where a mill is along the technology pathway presented in Recommendation 3.**	**1994 Supplier Annual Monthly Average**	**1994 Supplier Process Variability (Percentage)**	**1995 Supplier Annual Monthly Average**	**1995 Supplier Process Variability (Percentage)**	**1996 Supplier Annual Monthly Average**	**1996 Supplier Process Variability (Percentage)**
Bleach Plant Effluent Flow Unit of measure = gallons/ton of air-dried pulp						
Adsorbable Organic Halogens (AOX) Unit of measure = kg/metric ton of air-dried pulp						
Chemical Oxygen Demand (COD) Unit of measure = kg/metric ton of air-dried pulp						
Dioxins (in bleach plant filtrates) Unit of measure = picograms/liter of water (parts per quadrillion)						

All data should be provided on a per ton of product manufactured basis.
The monthly average provides information about the mill's level of performance. As mills implement pollution-prevention technologies, the magnitude of the performance indicators should decrease.
The variability provides some information about the mill's ability to control the manufacturing process. Improved process control, maintenance and housekeeping should reduce the variability of these indicators over time.
Information can be provided on a *specific mill basis* or on an *aggregated basis at the division or company level.*

ENDNOTES

[1] National Renewable Energy Laboratory, *Technology Partnerships: Enhancing the Competitiveness, Efficiency and Environmental Quality of American Industry*. Report produced for the Department of Energy, report number DOE/GO-10095-170, April 1995, p. 35.

[2] Hardwoods contain about 45% cellulose and 20% lignin. They yield a short fiber pulp that provides a smooth printing surface and opacity to a sheet of paper. Softwoods contain about 42% cellulose and 28% lignin.

[3] Gary Smook, *Handbook for Pulp & Paper Technologists, 2nd ed*., Vancouver, BC: Angus Wilde Publications, 1992, chapter 2.

[4] The different grades of recovered paper are defined in the Institute of Scrap Recycling Industries, Inc's., *Scrap Specifications Circular 1994; Guidelines for Paper Stock: PS-94; Domestic Transactions*, Washington, DC: Paper Stock Industries Chapter Institute (1994), pp. 33-34. See Paper Task Force White Paper No. 2 for more information.

[5] These two chemical pulping processes combine sulfur and a metal alkaline base. For the kraft process, the base is sodium hydroxide: for papergrade sulfite processes it is calcium, ammonium, magnesium or sodium hydroxide.

[6] Sodium hydroxide.

[7] Chemicals used to facilitate the manufacturing process include sizing to facilitate the drainage of water from the pulp on the paper machine, biocides to suppress the growth of fungi and bacteria in the warm, wet paper mill environment, and starches to help bind fibers together in the paper sheet.

[8] Specifically, a 2,200-square-foot home. National Renewable Energy Laboratory, *Technology Partnerships*, p. 15.

[9] U. S. EPA, *Development Document for Proposed Effluent Limitations Guidelines and Standards for the Pulp, Paper and Paperboard Point Source Category,* Washington, DC: U.S. EPA report No. EPA-821-R-93-019, October 1993, 6-48 - 6-49.

[10] See, for example, Gary Smook, *Handbook for Pulp & Paper Technologists, 2nd ed*.

[11] P. Sharman and G. Harris, "High Yield Pulping" *Mill Product News*, September-October 1994, p. 31.

[12] R. W. Johnson, "CTMP in Fine Papers: On-Machine Surface Treatments for Improved Brightness Stability" *Tappi Journal*, 74:5 (1991), p. 210.

[13] U.S. EPA, *Development Document for Proposed Effluent Limitations Guidelines*, p. 8-7.

[14] Gary Smook, *Handbook for Pulp & Paper Technologists, 2nd Ed.*, p. 69.

[15] Sulfite mills can use four different types of alkali: calcium hydroxide, ammonium hydroxide, sodium hydroxide and magnesium hydroxide. Calcium based sulfite processes have the lowest chemical costs because lime and sulfur are readily available; however, there is no chemical recovery process for the used pulping chemicals. Mills with a calcium-based process often sell the lignin by-products, and, thus, find a beneficial use for this waste. Of the 14 papergrade sulfite mills operating in the United States, 5 use ammonium hydroxide, 5 use magnesium hydroxide and 4 use calcium hydroxide. Gary Hickman and Llewellyn Matthews, "Bleached Sulfite Mill Effluent and AOX Treatment," *TAPPI proceedings: 1995 International Environmental Conference*, Atlanta: TAPPI Press, 1995, p. 475; 1995 *Lockwood-Post's Directory of Pulp and Paper Manufacturers and Allied Trades*, San Francisco: Miller Freeman, Inc., 1994.

[16] One manufacturer of mottled white linerboard also uses a deinking system to obtain white pulp; an additional linerboard mill is installing this technology in 1995.

[17] National Council of the Paper Industry for Air and Stream Improvement (NCASI), "Effects of Chlorine Dioxide Substitution on Bleach Plant Effluent BOD and Color," *Technical Bulletin No. 630*, March 1992, p. 3.

[18] Estimate based on U.S. mill consumption of "old corrugated containers" and "mixed paper" recovered paper categories. Preliminary 1994 data; American Forest & Paper Association, *Paper, Paperboard and Wood Pulp, 1995 Statistics*, Washington, DC: AF&PA, September 1995, p. 57.

[19] Using hydrogen peroxide or FAS compounds.

[20] White Paper No. 9, "Economic of Manufacturing Virgin and Recycled Paper," provides more information on the percentage of deinked pulp made with TCF processing.

[21] National Renewable Energy Laboratory, *Technology Partnerships*, p. 61.

[22] Ibid., pp.38, 61.

[23] NCASI, "Solid Waste Management and Disposal Practices in the U.S. Paper Industry," *Technical Bulletin No. 641*, September 1992.

[24] J.T. Houghton et. al. (eds.), Climate Change 1994: Radiative Forcing of Climate Change and An Evaluation of the IPCC IS92 Emissions Scenarios, Cambridge, England: published for the Intergovernmental Panel on Climate Change by Cambridge University Press, 1995, chapter 1.

[25] U.S. EPA, *Regulatory Impact Assessment of Proposed Effluent Guidelines and NESHAP for the Pulp, Paper and Paperboard Industry*, Washington, DC: U.S. EPA Report number EPA-821-R93-020, November 1993, p. 7-8.

[26] Hydroelectric power, created by damming rivers, has environmental effects other than those associated with combustion processes.

[27] Allan Springer, *Industrial Pollution Control: Pulp and Paper Industry, 2nd ed.*, Atlanta: TAPPI Press, 1993, p. 346.

[28] The recovery boiler is a $75 million piece of equipment with complex operations. Across the total U.S. paper industry, major boiler explosions occur on average about once a year.

[29] Gary Hickman, and Llewellyn Matthews, "Bleached Sulfite Mill Effluent and AOX Treatment," *TAPPI Proceedings 1995 International Environmental Conference*, Atlanta: TAPPI Press, 1995, p. 469 - 481.

[30] MoDo's Dömsjö mill has operated without any bleach plant effluent since 1991. Carl-Johan Alfthan, "Pollution Reduction-Targets, Achievements and the Public", *Third Global Conference on the Environment*, London England, 26-28, March 1995, p.113

[31] American Forest & Paper Association, S*ustainable Environmental Pathways for the Pulp & Paper Industry: Development of Agenda 2020*, September 1995.

[32] B.J. Fuhr et al., " Research Developments for Zero Effluent Kraft Bleach Plants," *TAPPI Proceedings: 1995 International Environmental Conference* (Atlanta: TAPPI Press, 1995) pp. 149 - 158; Nils Johannson, F. M. Clark, and D.E. Fletcher, "New Technology Development for the Closed Cycle Bleach Plant," *Proceedings of the 1995 International Non-Chlorine Bleaching Conference*, Amelia Island, FL, March 1995.

[33] Tom Tibor and Ira Feldman, "ISO 14000 Standards," *Papermaker*, 58:10 (1995), p. 43.

[34] John E. Pinkerton, "Defining Pollution Prevention," *Tappi Journal*, 77:4 (1994), p. 12.

[35] *AF&PA Statistics of Pulp Paper & Paperboard, 1994*, pp. 26, 29.

[36] As discussed in White Paper No. 5, current research efforts are examining the effects of these chemicals on wild fish and other aquatic organisms. For example, Canadian scientists believe that the organic substances in the spent pulping liquor from pulp mills may impair the reproductive systems of wild fish downstream from pulp mills. These scientists have seen these effects downstream from mills that produce bleached and unbleached kraft pulp. Fish downstream from mills with secondary effluent treatment also have the same problems. [Hodson, et al., *Canada and Sweden – Contrasting Regulations for Chlorine Discharge from Pulp and Paper Industries*, Environment Canada, 8 July, 1994 draft. K.R. Munkittrick, and G.J. Van Der Kraak, "Receiving Water Environmental Effects Associated with Discharges from Ontario Pulp Mills," *Pulp & Paper Canada*, 95:59 (1994).]

[37] Bruce McKague, University of Toronto, personal communication, 17 February, 1994.

[38] *Canadian Environmental Protection Act Priority Substances List Assessment Report No. 2: Effluents from Pulp Mills Using Bleaching* (Environment Canada and Health and Welfare Canada, 1991), p. viii.

[39] NTP Invites Chemical Nominations, *Environmental Health Perspectives*, 102:11 (1994), p. 917.

[40] Scientists point to several factors that may limit the ability of ecosystem studies to show cause-and-effect relationships between pollutants and different species. Robert J. Naiman, et.al., "Fresh Water Ecosystems and Their Management: A National Initiative", *Science*, 270, 27 October 1995, p.585. For example, effects from changes in temperature, nutrient levels and other factors may obscure the effect of exposure to toxic substances. Many fish species of interest migrate hundreds of miles unless dams or other barriers limit their move-

ment. M.M. Gagnon, D. Bussieres, J.J. Dodson, and P.V. Hodson, "White Sucker (*Catostomus Commersoni*) Growth and Sexual Maturation in Pulp Mill-Contaminated and Reference Rivers," *Environmental Toxicology and Chemistry*, 14: 326 (1995).

41 John E. Pinkerton, "Defining pollution prevention," p. 12.

42 Michael Porter and Claas van der Linde, "Green and Competitive: Ending the Stalemate," *Harvard Business Review*, September-October 1995, p.122.

43 Ibid.

44 Chad Nerht, "Spend More to Show Rivals a Clean Pair of Heels," *Pulp & Paper International*, 37:6 (1995), pp. 81-82.

45 American Papermaker staff report, "Tried and True: North American experiences with ECF pulp production have been successful", *Papermaker*, 58:6 (1995), p.37.

46 Ken Patrick et al., "Closing the Loop: The Effluent-free Pulp and Paper Mill," *Pulp & Paper*, March 1994, p. S24.

47 Fleming and Sloan use literature sources in their analysis to develop their estimate of increased wood use of 9%-11% that results when mills produce TCF pulps with extended delignification. Bruce Fleming and Tod Sloan, "Low Kappa Cooking, TCF Bleaching Affect Pulp Yield, Fiber Strength," *Pulp & Paper,* 68:13 (1995), pp. 95-96. Steven Moldenius, technical director of Södra Cell, reported that the change in wood requirement was within the normal variability of their process, so they saw no change. S. Moldenius, "Panel Discussion on Pulp Quality and Economics of ECF vs. TCF Bleaching," 1995 International Non-Chlorine Bleaching Conference, Amelia Island, FL, March 7, 1995.

48 Resourc Information Systems, Inc., RISI Long-Term Pulp and Paper Review, Bedford, MA RISI, July 1995, p. 328-329.

49 Data collected at the division level should reflect specific products. For printing and writing papers, for example, logical categories would include coated and uncoated papers and freesheet and mechanical pulps.

50 Major global market pulp suppliers state that this is possible and is being requested with increasing frequency.

51 Faye Rice, "Hands Off the EPA! Did We Really Say That?" *Fortune* (September 18, 1995), p. 18.

52 Genevieve Matanoski, Morton Lippmann, Joan Daisey, "Science Advisory Board's review of the Draft Dioxin Exposure and Health Effects Reassessment Documents", Letter to Carol Browner, EPA-SAB-EC-95-021, September 29, 1995.

53 Dick Erickson, "Closing Up the Bleach Plant: Striving for a Minimum-Impact Mill," Paper presented at the 1995 Chemical Week Conference, New Orleans, LA, 11 April 1995.

54 NCASI, "Effects of Chlorine Dioxide Substitution on Bleach Plant Effluent BOD and Color," *Technical Report No. 630*, March 1992, pp. 18, 21; Ted Y. Tsai, Jean J. Renard, and Richard B. Phillips, "Formation of Polychlorinated Phenolic Compounds During High Chlorine Dioxide Substitution Bleaching Part I: Laboratory Investigation," *Tappi Journal*, 77:8 (1994), p. 154.

55 Alan E. Stinchfield and Michael G. Woods, "Mill Experience with Reduction of Chlorinated Organic Compounds from Bleached Kraft Mills Using Complete Substitution of Chlorine Dioxide for Chlorine in the First Bleaching Stage," *NCASI Technical Workshop on Effects of Alternative Pulping and Bleaching Processes on Production and Biotreatability of Chlorinated Organics*, Washington, DC, 17 February 1994, p. 5; John Morgan, "Mill Experience with 100% ClO_2 Substitution Bleaching," 1993 Non-Chlorine Bleaching Conference, Hiltonhead, SC, p. 5. Estimate of AOX from the bleach plant is based on the final effluent AOX number from this source and using treatment efficiency of 22% as reported by Stinchfield and Woods.

56 Wells E. Nutt, et. al., "Developing an Ozone Bleaching Process," *Tappi Journal*, 76:3(1993), p. 117.

57 Jean Renard, technical meeting with the Paper Task Force, Newark, NJ, 1 September 1994.

58 Ibid.; Rudolph Thut, "Performance of Weyerhaeuser Bleached Kraft Mills with Extended and/or Oxygen Delignification and 100% Chlorine Dioxide Substitution," *NCASI Technical Workshop on Effects of Alternative Pulping and Bleaching Processes on Production and Biotreatability of Chlorinated Organics*, Washington, DC, 17 February 1994, p. 3.

59 Dick Erickson, "Closing Up the Bleach Plant"; Jean Renard, technical meeting with the Paper Task Force, Newark, NJ, 1 September 1994.

60 Wells Nutt, president, Union Camp Technologies Inc., letter

to Harry Capell, 12 July 1995, p. 6.

[61] Betsy Bicknell, Douglas Spengel, and Thomas Holdworth, "Comparison of Pollutant Loadings from ECF, TCF and Ozone/Chlorine Dioxide Bleaching," *1995 International Non-Chlorine Bleaching Conference*, p. 16.

[62] G. Maples et al., "BFR: A New Process Toward Bleach Plant Closure," *Papers presented at the 1994 International Pulp Bleaching Conference*, Vancouver, BC, 13-16 June 1994, pp. 253 - 262.

[63] Estimate based on discussion in G. Maples et. al., "BFR: A New Process Toward Bleach Plant Closure."

THE PAPER TASK FORCE MEMBERS

Each Paper Task Force member organization dedicated to the project a team of individuals who worked with people from other member organizations and collectively wrote this report. These individuals are listed below.

Duke University

Paul Brummett is the director of the Material Support Department at Duke University. In this capacity, he is responsible for purchasing and materials services. Over the past 30 years, Mr. Brummett has headed Purchasing/Materials Management operations at York Division of Borg Warner Corporation, the University of Rochester and Duke University. He holds bachelor's and master's degrees from Ball State University.

Evelyn Hicks is a senior buyer in the Material Support Department with 29 years of experience in purchasing. She is responsible for the purchase of forms and other paper requirements.

Environmental Defense Fund (EDF)

Lauren Blum is a senior scientist in the Environmental Defense Fund's New York City office. Before joining EDF in 1992, she was an associate in the Energy and Chemicals Group at Booz•Allen & Hamilton, Inc., a management consulting firm in New York City. Dr. Blum has an A.B. in chemistry from Harvard University, a Ph.D. in inorganic chemistry from the Massachusetts Institute of Technology and a master's degree in public and private management from Yale University.

Robert Bonnie is an economist for the Environmental Defense Fund and focuses on land incentives for endangered species protection. Mr. Bonnie has master's degrees in resource economics and forestry from Duke University and a bachelor's degree in American history from Harvard University.

Richard A. Denison is a senior scientist at the Environmental Defense Fund in Washington, D.C., where his areas of work include materials use policy and waste management. He has authored many papers on waste reduction, recycling, incineration and landfilling, and has co-authored a recent book entitled *Recycling and Incineration: Evaluating the Choices* (1991). Dr. Denison, who holds a doctorate in biochemistry from Yale University, was a member of EDF's joint waste reduction task force with McDonald's Corporation.

Nat Keohane joined the Environmental Defense Fund as a research assistant on the Paper Task Force. He graduated from Yale College with a degree in history and studies of the environment and worked at the Environmental Working Group in Washington, D.C. Mr. Keohane currently is a first-year Ph.D. student in the political economy and government program at Harvard University.

Annette Mayer-Ilmanen holds a master's degree in economics and business from the University of St. Sallen, Switzerland, and a M.B.A. from the University of Chicago. Before joining the Environmental Defense Fund's New York office, Ms. Mayer-Ilmanen worked for four years as a management consultant at the Boston Consulting Group in Germany and Chicago.

Jane B. Preyer is a public policy specialist in the Environmental Defense Fund's North Carolina office. She was the project coordinator for the Paper Task Force. Ms. Preyer received her B.A. and master of public administration degrees from the University of North Carolina at Chapel Hill.

John F. Ruston is an economic analyst in the Environmental Defense Fund's New York office. Mr. Ruston was a member of the EDF-McDonald's waste reduction task force. He has worked on recycling issues in New York City and is co-author of *Recycling and Incineration: Evaluating the Choices* (1991). Mr. Ruston holds a master of city planning degree (environmental policy specialization) from MIT, and received his B.S. from the University of California at Davis.

Melinda Taylor is the director of and senior attorney at the North Carolina office of the Environmental Defense Fund. She oversees that office's work on air quality, water, wetlands, wildlife and toxics issues. Before joining EDF, Ms. Taylor was a partner in the Austin, Texas law firm Henry, Lowerre & Taylor. Prior to that, she was the deputy general counsel of the National Audubon Society in Washington, D.C. Ms. Taylor received her B.A. and J.D. degrees from the University of Texas at Austin.

Johnson & Johnson (J&J)

Harold J. Capell is currently vice president, engineering and operations support, for Johnson & Johnson's Worldwide Absorbent Products and Materials Research organization. For more than 20 years he has held numerous manufacturing, purchasing and engineering positions within J&J's absorbent products businesses. In his current position, Mr. Capell is responsible for manufacturing process improvements for the worldwide feminine hygiene and incontinence products businesses.

Brenda S. Davis is vice president, government operations, and a member of the management board of Johnson & Johnson Health Care Systems, Inc. She is responsible for government sales, state government affairs, reimbursement services and pharmaceutical rebate management for the domestic health care businesses. Dr. Davis previously was a visiting fellow at Princeton University, served in the cabinet of Governor Thomas H. Kean of New Jersey and was a senior staff member of the U. S. Senate Committee on the Budget. She holds a Ph.D. in ecology from the University of California at Berkeley.

Barbara M. Greer, an attorney and professional planner, is an environmental consultant to Johnson & Johnson. In addition to her other duties, Ms. Greer assists the J&J Paper Task Force team. Prior to becoming an independent consultant, Ms. Greer was, successively, chief regulatory officer of the New Jersey Department of Environmental Protection and deputy chief of policy and planning for Governor Thomas H. Kean of New Jersey.

Anthony A. Herrmann is vice president, worldwide environmental affairs for Johnson & Johnson. He is an associate clinical professor, Department of Environmental and Community Medicine, Robert Wood Johnson Medical School. Dr. Herrmann has extensive research experience in the field of environmental toxicology.

Peter Turso is director of strategic sourcing at Johnson & Johnson's world headquarters in New Brunswick. He has 15 years experience dealing with the pulp and paper industry in a variety of procurement positions. Mr. Turso is also responsible for coordination of fiber packaging purchases in the U.S. and Europe.

McDonald's Corporation

Linda Croft joined the Perseco Company, the exclusive packaging purchaser for McDonald's, in 1988 and is responsible for managing a full range of projects related to environmental and regulatory issues for Perseco and McDonald's. Ms. Croft received her B.A. from the University of Notre Dame and, at the completion of the Paper Task Force, will leave McDonald's to pursue a master's degree in wildlife biology.

Bob Langert, as director of environmental affairs for McDonald's Corporation, has led the company's environmental programs and initiatives since 1991. Mr. Langert headed McDonald's environmental management of packaging beginning in 1988, after joining the McDonald's system in 1983, working in various distribution and transportation management functions.

The Prudential Insurance Company of America

Joe DeNicola is a vice president in The Prudential's financial restructuring group where he manages a portfolio of independent energy projects. In addition to his portfolio responsibilities, Mr. DeNicola has been involved with several environmental initiatives at The Prudential. Mr. DeNicola received a B.A. degree in chemistry from Yale University in 1986 and expects to complete a master's of forestry degree at the Yale School of Forestry and Environmental Studies in 1996.

Steve Ritter is an associate manager in The Prudential's supplier management & purchasing services division. Mr. Ritter oversees vendor relations and purchasing for a number of paper products including copy paper, personalized stationery and other printed materials. He received a B.S. in finance and management information systems from the State University of New York at Buffalo in 1988 and has been with The Prudential for six years.

Time Inc.

David J. Refkin is director of paper purchasing and environmental affairs for Time Inc. In addition to his responsibilities for purchasing magazine and book paper, he has served as a member of numerous committees on issues concerning paper and the environment, including the Recycling Advisory Council. Mr. Refkin, a C.P.A., holds a B.S. in accounting from the State University of New York at Albany and a M.B.A. in finance from Iona College. He is completing his studies in the strategic environmental management program at New York University.

David Rivchin has been in publishing and paper purchasing for more than 20 years. He has worked at Time Inc., Book of the Month Club, Random House and Scholastic Inc. Mr. Rivchin earned his bachelor's degree from Boston University.

EXPLANATION OF KEY TERMS AND ABBREVIATIONS

Note: Terms listed and defined below are in **boldface**. Terms which may be of particular interest to the reader in a given context, but are not defined below, are in *italics*.

Adsorbable organic halogens (AOX): Measure of the total amount of halogens (chlorine, bromine and iodine) bound to dissolved or suspended organic matter in a wastewater sample. For pulp, paper and paperboard wastewaters, essentially all of the organic substances measured as AOX are chlorinated compounds that result from the bleaching of pulps with chlorine and chlorinated compounds such as **chlorine dioxide** and **hypochlorite**. AOX provides information about the quantity of chlorinated organic compounds in wastewater, and thus contains a broad mix of compounds that have different chemical properties. The actual composition of AOX in pulp mill **effluent** varies from mill to mill, depending on the wood species used and the process parameters.

"Although AOX concentrations can be used to determine the removal of chlorinated organics to assess loading reductions, they do not provide information on the potential toxicity of the effluent, and therefore, are not appropriate to evaluate the potential impacts on the environment. Although no statistical relationship has been established between the level of AOX and specific chlorinated organic compounds, AOX analysis can be an inexpensive method for obtaining the 'bulk' measure of the total mass of chlorinated organic compounds." (U.S. EPA, *Regulatory Impact Assessment of Proposed Effluent Guidelines and NESHAP for the Pulp, Paper and Paperboard Industry,* (Washington: Office of Water, EPA-821-R93-020, November 1993), pp. 7-25 - 7-26)

AF&PA: American Forest & Paper Association

Agricultural residues: By-products from the production of food and other crops that contain fibers that can be used for papermaking.

Air-dried metric tons (ADMT): Pulp with 10% water content by weight. One ADMT is equivalent to 0.9 **oven-dried metric ton of pulp (ODMT)**.

Air-dried tons of final product (ADTFP/ADMTFP): Tons or metric tons of final product made at a mill.

Alkaline papermaking: Process of producing papers under neutral or alkaline conditions. The major force behind the conversion from acid to alkaline papermaking is the greater strength of the alkaline sheet, which permits higher levels of **clay** and calcium carbonate **filler**. Additionally, maintenance costs for alkaline papermaking are less because such systems are less prone to corrosion, and are more easily closed than acid systems.

Alum: Also called *aluminum sulfate*. (1) Chemical release agent, used when pure **fiber furnish** is run at low **basis weight** to prevent sticking to the paper machine **presses**. (2) Papermaking chemical commonly used for precipitating rosin **sizing** onto pulp fibers to impart water-resistant properties to the paper.

American Forest & Paper Association: The trade association for the U.S. pulp, paper and forest products industry.

Anaerobic: Biochemical process or condition occurring in the absence of oxygen.

Anthraquinone: Chemical added to the **digester** that increases the amount of **lignin** removed from **kraft pulp** while maintaining its strength.

Artificial regeneration: Method for producing a new **stand** of trees following **harvesting**, in which tree seedlings (or more rarely, seeds) are planted. Most often used in **even-aged silvicultural** systems.

Ash: Inorganic matter present in the paper sheet, such as **clay** or **titanium dioxide**.

Base stock: Paper that will be further processed, as in **coating** or laminating.

Basis weight: The weight of a **ream** (500 sheets) or other standardized measure of a paper. Calculations are based on different sheet sizes, because paper mills produce the larger-size sheets and then ship them to **converters**, who cut the sheets to standard letter or legal sizes. A proposed international standard unit for basis weight is called *grammage*, which is grams per square meter; this international standard unit is not widely used in the U.S.

Beating: The mechanical treatment given papermaking materials to prepare them for forming on the paper machine into paper or board of precise characteristics.

Bedding: Site-preparation technique in which soil is raised from a few inches to a few feet high to provide an elevated planting or seed bed; used primarily in wet areas to improve drainage and aeration for seeding.

Best Management Practices or BMPs: In this report, forestry practices specified in state-level forest management guidelines or legislation. BMPs encompass the practices required by the mandatory forest practice acts in some states as well as the voluntary or quasi-regulatory BMP programs in other states.

Biochemical oxygen demand (BOD): Amount of oxygen required by aerobic (oxygen-requiring) organisms to carry out normal oxidative metabolism or the amount required by oxidation of metabolic by-product from anaerobic organisms in water containing organic matter. Thus, BOD measures the amount of dissolved organic material that is degraded naturally once it enters a mill's receiving waters. For regulatory purposes, BOD is most often measured over a five-day period in the United States. The BOD in a test bottle can consume oxygen well in excess of 100 days, and the five-day test may capture only 50-75% of the total BOD.

Biodiversity: Most broadly, biodiversity encompasses the diversity of life on the planet. Biodiversity includes *genetic diversity*, the diversity of information encoded in genes within a species; species diversity, the diversity and relative abundance of species; and community/ecosystem diversity, the diversity of natural communities.

Biomass: Mass of organic matter. E.g., the "biomass removed in harvesting" refers to the amount of organic matter — mostly wood in trees, but also twigs and leaves — removed at harvest.

Black liquor: Spent, lignin-rich cooking liquor generated in the kraft pulping process.

Bleached chemi-thermomechanical pulp: A stronger and brighter variation of chemi-thermomechanical pulp (TMP), a pulp that reduces energy consumption for certain paper grades by combining thermal pretreatment with chemical methods.

Bleaching: Chemical treatment of pulp fibers for the purpose of: (1) increasing pulp brightness, (2) improving cleanliness by disintegrating contaminating particles such as bark, and (3) improving brightness stability by reducing the tendency of bleached pulp to turn yellow. Bleaching removes residual lignin.

Bonding strength: Cohesiveness of fibers within a paper. Paper with good bonding strength will not pick during the printing process.

Book paper: Also called text paper. Any type of paper suitable for printing, exclusive of newsprint and boards.

Boxboard: Paperboard used to make folding boxes, set-up boxes and carton stock. May be plain, lined or clay-coated.

Brightness: Light-reflecting property of paper or pulp. Brightness measurements compare paper and pulp with a reference standard (measured on a scale of 1 to 100 where 100 represents the reflectance of magnesium oxide). Bleached kraft pulps range in brightness from the low 80s to over 90. Unbleached mechanical pulps range from 55 to 62.

Broke: Machine trim or damaged paper that is pulped and returned to the papermaking process within the mill.

Broker: Purchaser of secondary materials who sells the materials to manufacturers. Brokers typically do not process raw materials for resale.

Buffer strip: See streamside management zone.

Bulk: Thickness of a sheet of paper in relation to its weight.

Bursting strength: Measurement of the strength of a piece of paper to withhold pressure.

Business papers: Office papers such as reprographic paper, letterhead, and envelopes designed to run in copiers and laser and ink-jet printers. May include some offset grades such as offset business forms and envelopes.

Buy-back center: Facility that purchases secondary materials, usually from the public, and resells them to **brokers** or manufacturers. Buy-back centers may or may not process the recyclables.

Cable logging: System of transporting logs from stump to **landing** by means of steel cables and winch. This method is usually preferred on steep slopes, in wet areas, and for erodible soils where tractor logging cannot be carried out effectively.

Calender: Also called *calender stack*. Vertical stack of sheet or cast-iron rolls, in the **dry end** of the machine, through which the paper sheet is passed for smoothing and gloss improvement.

Calendering: The process of passing paper through an assembly of rolls that have polished surfaces. The rolls compact and smooth the paper, increasing the sheet's gloss and **smoothness**.

Caliper: Sheet thickness measured under specified conditions, usually expressed in thousandths of an inch (**points** or mils).

Capacity: The amount of pulp, paper or paperboard that a paper machine or mill is capable of producing over an extended period of time with the full use of its equipment, adequate raw materials and labor and full demand for its products. Capacity usually is slightly higher than actual production.

Carbon black: Finely processed forms of carbon derived from the incomplete combustion of natural gas or petroleum; used principally in ink and rubber.

Carbon dioxide (CO_2): Greenhouse gas associated with global climate change that results from the complete combustion of **biomass** and fossil fuels.

Cellulose: Polymer of sugar units that forms transparent, hollow and flexible tubes. It is the most abundant natural polymer produced by plants.

Chemi-thermomechanical pulp (CTMP): Variation of **thermomechanical pulp** (TMP) produced by pulping that reduces energy consumption for certain paper grades by combining thermal pretreatment with chemical methods. A stronger and brighter version of CTMP is **bleached chemi-thermomechanical pulp (BCTMP).**

Chemical oxygen demand (COD): Amount of oxidizable compounds (composed of carbon and hydrogen) present in the water. Since an **effluent**-treatment system removes most of the organic material that would be degraded naturally in the receiving waters, the COD of the final effluent provides information about the quantity of more **persistent** substances discharged into the receiving water.

Chemical pulp: Pulp produced from wood that has been cooked with various chemicals; used to produce many grades of printing papers and some paperboard grades, such as **SBS.**

Chipboard: Low-density board made from waste paper; used in low strength applications.

Chlorine: See **elemental chlorine.**

Chlorine dioxide (ClO_2): Powerful oxidizing agent used to **delignify** and remove colored substances from pulp. The oxygen in chlorine dioxide initially reacts with **lignin**. This initial reaction produces substances that can chlorinate the remaining organic material.

Chloroform: A hazardous air pollutant, is classified as a probable human carcinogen. The units of measure are pounds per **oven-dried ton of pulp**.

Chopping: Mechanical **site preparation** treatment whereby remaining vegetation is concentrated near the ground and incorporated into the soil to facilitate burning or establishment of seedlings.

Clarifier: Process water storage tank in which **suspended solids** are allowed to settle.

Clay: Natural, fine-grained material used as **filler** and as **coating** pigments in paper manufacture.

Clean Air Act: Federal statute that gives the U.S. Environmental Protection Agency the authority to regulate emissions of air pollutants from all sources in the United States. The purpose of the statute is to protect and enhance the quality of the nation's air resources. 42 U.S.C. §§ 7401 to 7642.

Clean Water Act: Federal statute that gives the U.S. Environmental Protection Agency the authority to regulate discharges of pollutants from all sources into waters of the United States. The purpose of the statute is to restore and maintain the chemical, physical and biological integrity of the nation's waters. 33 U.S.C. §§ 1251 to 1387.

Clearcutting: Harvesting/regeneration method in which all merchantable trees (commercial clearcutting) or all trees (silvicultural clearcutting) in a stand are harvested in one operation. Clearcutting is also used in even-aged silviculture to regenerate an even-aged stand of desired shade-intolerant trees. In practice, most clearcuts are commercial clearcuts.

Coarse woody debris: Also called large *woody debris*. Downed large wood on the forest floor, such as fallen trees and limbs. When such debris falls into streams, it creates waterfalls and pools — important physical structures for fish habitat and other stream functions. In natural forests of some regions (e.g., the Pacific Northwest), coarse woody debris on the forest floor also provides important functions as it slowly decays, returning nutrients to the soil, storing water for use in dry periods, and providing animal habitat. Coarse woody debris develops naturally in unmanaged forests, as trees die and decay, and may also be created by forest management (see also Logging debris).

Coastal Zone Management Act: Federal statute that requires states to formulate programs to reduce water pollution from nonpoint sources impacting coastal waters, including forestry activities. State management measures can include land use management restrictions and control measures similar to the Best Management Practices developed under the authority of the Clean Water Act. 16 U.S.C. 1451 *et seq*.

Coated freesheet: Coated papers containing 10% or less of mechanical pulp (mostly stone groundwood and/or refiner) in their furnish.

Coated groundwood: Coated papers containing more than 10% mechanical pulp (mostly stone groundwood and/or refiner). Coated groundwood papers also contain softwood bleached kraft pulp to minimize breaks in the printing press.

Coated paper: Paper or paperboard that has been coated to improve printability and appearance. Paper may be coated on one or both sides.

Coating: (1) Act of applying a coating to the surface of paper or paperboard. (2) Material used as a coating; clay is the most commonly used coating.

Cockle: Ripple or waviness of a sheet caused by improper drying.

Color: Used to describe colored wastewater discharge from chemical pulping, pulp bleaching or colored-paper manufacture. The wastewater is colored by the lignin and lignin derivatives present in spent cooking liquors.

Commercial printing: Wide array of promotional literature, including annual reports and direct mail products not included under catalogs, such as materials sent out in bulk mail by banks, financial services companies, credit-card marketers and others. Commercial printing products use both uncoated and coated papers.

Commercial thinning: Silvicultural practice performed in even-aged forests in which some merchantable trees are harvested, usually for pulpwood, to provide greater light, soil moisture and nutrients to the remaining stand.

Commodity grade: Mass-produced paper grades, typically made at large pulp and paper mills. Includes grade with more than 1.5 million tons per year of total production in the United States, such as linerboard, newsprint, and the major uncoated freesheet grades (e.g., 20 lb. cut-size, 50 lb. offset).

Community: Collection of animal and plant species present in a given location; generally viewed as also encompassing the interactions between different species.

Compost: (1) Nutrient-rich mulch of organic soil produced through aerobic digestion of mixtures of food, wood, manure and/or other organic material. (2) The process of producing compost.

Consistency: The percentage of cellulose fibers in a pulp slurry.

Containerboard: Single-ply and multi-ply combinations of linerboard, and corrugating medium used to make boxes and other shipping containers.

Conversion: Transformation of large rolls of paper or paperboard into a variety of products, such as forms, envelopes, bags, boxes and folding cartons.

Converter: Company that converts paper from its original form into usable products like bags and boxes.

Cook: To treat wood with chemicals, under pressure and/or extreme heat, to produce pulp for making paper and paperboard.

Cooking liquor: Chemical solution used to pulp wood.

Core: In the center of a roll, the shaft around which the web of paper is wound. Cores are either metal or cardboard and are either returnable or disposable.

Corrugating medium: Paperboard (made from chemical, semi-chemical and/or recycled pulps) that is passed through a fluting machine and used as the middle layer of corrugated boxes.

CUK: Coated unbleached kraft paperboard. Also known as solid unbleached sulfate or coated natural kraft paperboard. The abbreviations "SUS" and "CNK" are trademarks.

Cumulative effect: Impact on the environment that results from the incremental impact of an action when added to other past, present and reasonably foreseeable future actions.

Curl: In a photocopy machine, *output curl* is a result of an interaction of the heating in the fuser with the paper's structure and moisture content. Curl that is built into the paper as packaged is called *as-packaged curl*.

Cylinderboard: Paperboard made on a cylinder machine.

Cylinder machine: An older paper machine technology used primarily to make 100% recycled paperboard. In such a machine, 6-9 rotating mesh cylinders are immersed in vats of pulp; the paperboard is formed as water drains from the cylinder. The wet sheet is transferred off the cylinder onto a felt or onto other sheets to make a multi-layer product. Pressing and drying follow this step.

Deinked market pulp (DMP): Pulp made from recovered paper by mills that receive high-grade recovered papers and remove the ink and contaminants. DMP is produced in sheets as *wet-lap pulp* (about 50% moisture) or air-dried form and is sold to paper producers who blend it with virgin pulp for use on existing paper machines.

Deinking: Separation and removal prior to paper formation of ink and other contaminants from wastepaper slurry by screening, washing, flotation, chemical treatment and bleaching.

Delignification: The process of removing lignin from wood or non-wood fibers.

Density: The weight of a paper compared to its volume. Dense papers are made from well-beaten or hydrated pulp.

Die cut: Paper and paperboard products cut by a metallic die to specified dimensions or forms.

Digester: Pressurized vessel in which wood chips are cooked to separate fibers from each other and to remove contaminants.

Dimensional stability: Ability of paper to retain its dimensions in all directions under the stress of production and changes in humidity. This property allows paper to resist curl and cockle. Resistance to curl is extremely important, as curl is a major cause of copy machine jams. Dimensional stability is also determined by a sheet's reactivity and paper formation.

Dioxins: A group of persistent, toxic substances, including furans, that are produced in trace amounts when unbleached pulp is exposed to elemental chlorine. Term used to describe the families of chemicals known as chlorinated dibenzo-p-dioxins and dibenzo-p-furans. These families consist of 75 different chlorinated dibenzo-p-dioxins and 135 different chlorinated dibenzo-p-furans. These molecules can have from one to eight chlorine atoms attached to a planar carbon skeleton. 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and 2,3,7,8-tetrachlorodibenzofuran (TCDF) are two of the most toxic members of this family of compounds. If dioxins are detected in the releases from bleaching processes that expose unbleached pulp to elemental chlorine, the dioxins are most likely to be TCDD and TCDF.

Dirt: Loose material from all manufacturing sources, e.g., slitter or trimmer dust, lint, starch, loose coating pigments and loosely bonded fibers. With respect to paper recycling, dirt can refer to a range of small contaminants.

Disking: Also called *harrowing*. Mechanical site preparation method of scarifying the soil (i.e., scraping to expose mineral soil) to reduce competing vegetation and to prepare a site to be seeded or planted.

Downtime: Downtime occurs when a paper machine is stopped for repairs. Shutting down a paper machine for vacation or normal maintenance is referred to as *scheduled downtime*.

Drop out: Condition that occurs during photocopying when portions of originals do not reproduce, especially colored lines or background areas.

Dry end: Section of a paper machine where the driers, cutters, slitters and reels are located; the paper web is formed into a dry sheet in this part of the machine.

Dryers: Part of paper machine where water is removed from wet paper by passing it over rotating, steam-heated, cylindrical metal drums, or by running it through a hot air stream.

Ecosystem: Ecosystems encompass plant and animal communities and also include nonliving components, both structural (soil types) and functional (processes such as disturbance patterns and energy flows in and out of the ecosystem).

Effluent: Wastewater that has been discharged either to a sewer or to a stream or other body of water.

Electrical properties: Properties of paper that determine how it responds to an electrical charge, and how static electricity will be dissipated from the sheet. Electrical properties affect the quality of the image transfer in copy machines and laser printers. If the sheet does not exhibit uniform electrical properties, the result can be uneven application of toner on a page. Electrical properties are affected by the smoothness of the sheet, by surface sizing agents and by changes in moisture content.

Elemental chlorine: Chlorine gas (Cl_2).

Elemental chlorine-free (ECF): Bleaching processes that substitute chlorine dioxide for elemental chlorine and sodium hypochlorite in the bleaching process.

Endangered Species Act: Federal statute that seeks to protect plants and animals in danger of extinction (*endangered species*) or likely to become so (*threatened species*). It requires all federal agencies, including federal forestland managers, to ensure that their actions not jeopardize the continued existence of any endangered or threatened species. It also prohibits all persons (including public and private land owners) from "taking" any protected species, either directly or indirectly by destroying the habitat upon which the species depends. 16 U.S.C. 1531 *et seq*.

Even-aged management: Class of silvicultural systems that maintains even-aged stands by periodically removing the forest canopy in a single operation and regenerating a new stand at one time. Harvesting/regeneration methods used in even-aged management include clearcutting, the seed-tree method and the shelterwood method.

Feedstock: Raw material used to make paper or paperboard.

Feet per minute: Abbreviated as *fpm*, this term usually refers to the speed at which the forming paper web traverses the length of the paper machine.

Felt side: Top side (side opposite the wire) of a paper sheet. Felt is a woven belt made of cotton, metal or synthetic materials used to transport the paper web on the paper machine.

Fertilizer: Plant nutrients applied to forest soils, usually in chemical forms that are readily taken up by plants (e.g., phosphorus is applied as phosphate).

Fiber fractionation: Separation of pulp into a long and short fiber fraction. Used by paper and paperboard mills to direct long fibers to the outer plies and short fibers to the inner plies of a multi-ply board.

Fiber furnish: The pulps used to make paper or board.

Filler: (1) Substances, such as clay, precipitated calcium carbonate and other white pigments, added to pulp to improve a paper's printability. (2) Inner layers of multi-ply paperboards.

Filtrate: Water that is either pressed or washed out of the pulp during the pulping and bleaching; once the water has been discharged to a sewer it becomes effluent.

Fine papers: Printing and writing paper grades.

Finish: Surface contour and characteristics of a paper sheet measured in terms of smoothness, gloss, absorptiveness and print quality.

Finishing operations: Supplementary operations to printing such as binding, finishing and distribution. The demands of finishing and postpress operations include folding, die-cutting, cutting, trimming, scoring, stitching, gluing and perforating.

Flotation deinking: In a paper recycling system, removal of ink by a process of adding surfactants to the pulp and pumping bubbles of air through the mixture. The hydrophobic ink particles attach to the air bubbles, float to the surface of the pulp and are skimmed off.

Folding cartons: Paperboard boxes that are creased and folded to form containers that are generally shipped and stored flat and erected at the point where they are filled. Folding cartons are designed to contain and present products, and are generally small enough to hold in one hand.

Forest canopy: Topmost layer of tree vegetation, also called the overstory.

Formation: Term used to describe the process of forming the paper sheet or paperboard on a paper machine.

Fourdrinier machine: Paper machine comprised of a rapidly moving horizontal screen fitted with a headbox to meter the pulp onto the wire.

Freesheet: Paper that contains less than 10% groundwood pulp.

Freeness: Also called *drainage*. Ability of pulp and water mixture to release or retain water.

Fuelwood: Wood used for conversion to some form of energy, primarily residential use.

Functionality: Ability of a paper product to meet the user's performance requirements, such as running in office equipment, on an offset printing press, packaging consumer and industrial items, presenting a product or communication with a customer, and meeting the needs of the ultimate user.

Furans: See dioxins.

Furnish: Also called stock. Various pulps, dyes and additives blended together in the stock preparation area of a paper mill, and fed to the wet end of a paper machine to make paper or paperboard.

Groundwood pulp: Mechanical pulp produced by grinding pulpwood against a revolving grindstone, in the presence of water.

Group selection: Method of harvesting in which small groups of merchantable trees are cut periodically. Natural regeneration is typically relied on to fill in the resulting gaps.

Growing stock: Classification of timber inventory that includes live trees of commercial species meeting specified standards of quality or vigor; *cull trees* are excluded. When associated with volume, includes only trees 5.0" in *diameter at breast height* (d.b.h.) and larger.

Hardwood: Technically, a dicotyledonous tree. Hardwoods typically have broad leaves and are often *deciduous* (they lose their leaves during winter); e.g., maple, oak, aspen, cherry and ash.

Harvesting: In this report, the process of felling trees for removal and use. More broadly, may also be used to include related activities, such as the skidding, processing, loading and transporting of forest products.

Hazardous air pollutant (HAP): One of 189 toxic substances as defined by the 1990 Clean Air Act amendments.

Headbox: Box at the head of a fourdrinier machine that regulates the flow of pulp to the machine wire.

Heat-set inks: Inks used in high-speed web offset printing. They set rapidly under heat and are quickly cooled.

Herbicide: One of a group of chemicals used to kill or suppress unwanted vegetation, usually hardwood competition or brush.

Hickies: Blemishes or irregularities on the surface of the paper sheet.

Holdout: Ability of paper or board to resist penetration by liquid substances, such as ink.

Hot-melt glues: Rapidly setting glue made from plastic, resin and waxes melted at 350°F; frequently used to bind magazines and books. According to deinking experts, the most difficult contaminants to remove during deinking are the polymeric adhesives used as pressure sensitive adhesives and hot melt glues.

Hydrapulper: Large vat with agitator used to hydrate and prepare pulp or recovered paper for papermaking or fiber cleaning and processing.

Hydrogen peroxide (H_2O_2): Oxygen-based bleaching agent that removes colored substances but does not delignify pulp when used at low temperatures and pressures.

Hydrophilic: Affinity for water.

Hydrophobic: Aversion to water.

Ink holdout: Property of coated paper that allows ink to set on the surface with high gloss. If holdout is too high, it can cause set-off (transfer to the back of the previous sheet) in the paper pile.

Insecticide: One of a group of chemicals used to kill or control populations of unwanted insects.

Integrated mill: A mill that has facilities for producing both pulp and paper at the same site.

Intensive management: While forests can be intensively managed for any of a number of objectives, including wildlife habitat or recreation (e.g., hunting), "intensity" in the context of wood production relates to the extent to which specific yield-enhancing practices are employed. Intensity can characterize use of a particular practice, as well as the combination of practices that comprise the overall management system. It spans a spectrum from essentially unmanaged to highly intensive. At the latter end of the spectrum are softwood plantations which employ even-aged management and a suite of site preparation, artificial regeneration and stand-tending practices. Uneven-aged management systems may also vary in intensity with respect to, for example, the frequency of entries and the extent of removal of biomass at each entry.

Intermittent stream: Watercourse that flows in a well-defined channel only in direct response to precipitation; such a stream is dry for a large part of the year.

Job lot: Paper unsuitable for a customer's desired end use and usually sold at a discount. The term is also used to describe press overruns or defective and off-spec papers that are still usable.

Kaolin: White clay primarily comprised of the mineral kaolinite; used as a filler and coating pigment for papermaking.

Kraft mill: Mill that produces kraft pulp.

Kraft paper: High-strength paper made from unbleached sulfate (kraft) pulp; usually brown in color.

Kraft pulp: Also called sulfate pulp. Chemical pulp made using an alkaline cooking process with sulfur compounds. This pulp can be bleached or unbleached and is noted for its strength.

Landing: Also called *log deck* or *yard*. Place in or near the forest where logs are gathered for further processing or transport.

Latex: Milky substance, extracted from some species of rubber trees, used in the manufacture of paper and glue. Latex is used to make strong, durable, weather-resistant paper; latex glue is used to make self-seal envelopes.

lbsf/in: Pounds-force per square inch. A measure of bursting strength.

Leaching: Downward movement of a soluble material through the soil as a result of water movement.

Lightweight paper: Paper manufactured in weights below the minimum basis weight considered standard for that grade. High-brightness, high-opacity paper used by publishers of magazines, directories, Bibles, hymnals, reference books and catalogs.

Lignin: Complex organic material that binds together fibers in trees and woody plants.

Linerboard: Paperboard made from unbleached kraft pulp, recycled fibers, or a combination of the two, used to line or face corrugated core board (on both sides) to form corrugated boxes and other shipping containers.

Lint: Paper fragments or dust on the sheet. Excess lint can contaminate copiers and printers.

Lithography: Process of using a flat-surfaced plate that carries an image which is transferred to a blanket, then to paper. Also known as offset printing.

Logging debris: Also called slash. Accumulation of woody material, such as large limbs, tops, cull logs and stumps, that remains as forest residue after stem-only timber harvesting (as opposed to whole-tree harvesting). Logging debris is typically removed, displaced into piles, chopped, or burned during site preparation.

Logging residues: In this report, the portion of logging debris that is merchantable and that is removed from the site to be chipped for pulpwood or other uses. Logging residues typically make up a small fraction of total pulpwood supply.

Machine clothing: Paper-machine felt and wire.

Machine coating: Coating applied while paper or board is still on the paper machine.

Makeready: All work done to set up a press for printing.

Market pulp: Pulp sold on the open market; virgin market pulp is air-dried and wrapped; deinked market pulp can be sold in air-dried or wet-lapped (partially dry) form.

Materials recovery facility (MRF): Facility that upgrades recyclable materials for resale to manufacturers by separating, cleaning and baling incoming materials.

Mature forest: Stage in forest development in which the original dominant trees in the forest canopy begin to die and fall, creating canopy gaps that allow understory trees to grow, and providing coarse woody debris on the forest floor. Corresponds roughly to understory regeneration stage. Sometimes used more broadly to include old-growth forest.

Mechanical pulp: Pulp produced by shredding pulpwood logs and chips using mechanical energy via grindstones (groundwood pulp) or refiners (thermomechanical pulp).

Merchantable: Commercially valuable; merchantable timber has potential for sale as sawtimber, pulpwood, fuelwood or other wood products.

Mineral soil: Soil free of organic matter that contains rock less than 2” in maximum dimension.

Mixed Paper: An inclusive, “catch all” or “what’s left over” category for a wide variety of recovered paper blends. “Mixed paper” can refer to the commingled remnants of paper boxmaking or printing operations, or to office waste collected by haulers who removed some contaminants at a transfer station, or paper collected from households. The physical properties and intrinsic value of the paper are different in each case.

Moisture content: Percentage of moisture, by weight, found in a sheet of paper or paperboard, e.g., generally ranging from 5% to 8% in copy paper.

Multi-ply: Paper or paperboard sheet made of two or more layers.

Municipal solid waste (MSW): Includes durable goods, nondurable goods and containers and packaging that have served their useful life and have been discarded, plus food scraps and yard trimmings from residential, commercial and institutional sources. Strictly defined, MSW does not include construction and demolition debris, sludge, combustion ash and industrial process wastes.

Natural community: Discrete assemblage of interacting plants and animals, often referred to by their dominant plant associations: e.g., longleaf pine-wiregrass savanna; oak-hickory forest; beech-maple forest.

Natural disturbance: Naturally occurring events that disturb the forest by killing or felling one or more trees. *Natural disturbance regimes* — the typical natural disturbance patterns in a given region and forest type — vary by scale (individual tree mortality vs. wildfire over hundreds of acres), severity (light disturbance of the forest soil in a low-intensity fire vs. landslides that remove massive amounts of soil and organic matter, along with trees and vegetation), and frequency. Natural disturbance regimes typically determine the dominant forest types (which in turn help determine natural disturbance regimes): e.g., longleaf pine-wiregrass savannas in the southeast are maintained by and help to propagate frequent low-intensity ground fires.

Natural regeneration: Method for replacing trees removed through harvesting, in which new trees sprout from cut stumps or roots, or germinate from seeds present in the upper soil layer. May be used in both even-aged and uneven-aged silvicultural systems.

Newsprint: Relatively inexpensive groundwood paper made from mechanical pulp, thermomechanical pulp (TMP) or secondary fiber; used extensively by newspaper and directory publishers. Basis weights range from 30 to 35 lbs.

Nitrogen oxides (NO_x): Emissions that occur when fuels that contain nitrogen are burned. They also form at high temperatures from combustion of nitrogen in the air. Nitrogen oxides contribute to acid rain and can react with volatile organic compounds in the atmosphere to produce the ozone in photochemical smog.

Non-commercial species: Tree species typically of small size, poor form or inferior quality, that normally do not develop into trees suitable for industrial wood products.

Non-industrial private landowners: Private timberland owners other than forest-products companies and their subsidiaries.

Nutrients: Chemical elements required by plants for their growth and existence. Various nutrients are used for countless basic functions, such as manufacturing proteins and plant cells. The best-known plant nutrients include nitrogen and phosphorus. Low levels of key nutrients in soils can substantially limit plant growth and productivity. Nutrients may be added to soils in fertilizer to make up for inherent soil deficiencies.

OCC: Old corrugated containers.

Off-machine coating: Also known as *conversion coating*. Process of coating paper on a separate machine from the paper machine.

Office Paper: Wastepaper generated by offices, including stationery and computer paper.

Office pack: A more detailed definition of what is allowed and not allowed in sorted office paper developed by individual deinking mills for use by their recovered paper suppliers.

Offset paper: Paper made specifically for use on offset printing presses, characterized by strength, cleanliness, pick-resistance and relative freedom from curl. Offset paper must be relatively impervious to water.

Offset printing: Also called offset lithography or *photo-offset*. Indirect printing process that uses lithographic plates on which images or designs are ink-receptive; the rest of the plate is water-receptive. Ink is transferred from the plate to a rubber-blanketed cylinder that transfers (off-sets) the image to the paper.

Old-growth forest: The fourth and final stage of stand development, following mature forest, in which the forest canopy is generally composed of scattered remaining trees that assumed dominance following natural disturbance along with newly dominant, shade-tolerant trees. Other characteristics of old-growth forests may include accumulated coarse woody debris, snags and canopy gaps created by fallen trees. Because of these features, and the presence of an understory, old-growth forests generally exhibit complex stand vegetation, and provide habitat for many species. Development of old-growth forest generally takes from 100 to 200 years, with variation depending on forest type. The last remaining sizable area of old-growth forest in the contiguous United States lies in the Pacific Northwest; only a few small and isolated patches of old-growth remain in eastern forests. However, as a stage in stand development, old-growth forest could also develop in eastern forests (and was present in presettlement forests).

OMG: Old magazines.

ONP: Old newspapers.

Opacity: Also called *show-through*. Degree to which one is unable to see through the sheet; measured by the amount of light that transmits through a sheet. Opacity is a function of the type and amount of fiber, basis weight, sheet compaction, void volume and the inclusion of various fillers in the paper. Paper can have a maximum opacity of 100%, in which no light is transmitted at all. For duplexing and double-sided printing, opacity is an important characteristic.

Oven-dried ton/metric ton of pulp (ODTP/ODMTP): The moisture content of oven-dried pulp is zero. Air-dried pulps have about a 10% moisture content

Overstory: See forest canopy.

Ozone (O_3): Powerful oxidizing agent used in bleaching processes to remove lignin and colored substances from pulp. Ozone is formed by passing electricity through a stream of oxygen gas. Low-level atmospheric ozone is a pollutant in smog that results from the reaction of nitrogen oxides and volatile organic compounds with sunlight.

Paper machine: Machine on which pulp is made into paper; a sheet is dried and wound on rolls. (See cylinder machine and fourdrinier machine.)

Paper: Medium formed primarily from cellulose fibers in a water suspension, bound together with additives and formed on a wire machine. General term designating one of the two broad classifications of paper; the other is paperboard.

Paperboard: Comparatively thick, strong paper used to make such products as packaging, corrugated boxes, folding cartons and set-up boxes.

Particulates: Small particles that are dispersed into the atmosphere during combustion.

Perennial stream: Watercourse that flows throughout most of the year in a well-defined channel.

Persistence: Ability of a substance to remain active over a period of time.

Pesticides: Chemicals used in silviculture to control unwanted insects (insecticides) or unwanted vegetation (herbicides).

PIA: Printing Industry of America.

Picking: Fibers in the paper that tend to pull away from the surface during the printing process. Picking occurs when the tack or pull of the ink is greater than the surface strength of the paper. An increase in surface pick resistance is commensurate with an increase in bonding strength. Pick resistance is important in office papers that are run through the reprographic process in which excessive linting can cause impairment of copies.

Plantation: Planted stand of trees.

Pocosin: Freshwater evergreen shrub or forested bog found in the Atlantic coastal plain of the southeastern United States, primarily in the Carolinas. The term is taken from the Algonquin Indian word meaning “swamp on a hill.” Pocosins are generally found on flat, slightly elevated and very poorly drained areas between rivers, with either organic or acidic mineral soils.

Ply: One layer of paper or paperboard that makes up a multilayer (multi-ply) sheet.

Point: One thousandth of an inch equals one point; used to denote the caliper measurement of paper and paperboard.

Polyethylene: Thermoplastic film applied to paper to make it suitable for packaging; also applied to foodboard for liquid resistance.

Postconsumer fiber: Finished paper products that have been sold in commerce and have served their original purpose. As contained in the Resource Conservation and Recovery Act (RCRA), postconsumer material is “paper, paperboard and fibrous wastes from retail stores, office buildings, homes and so forth after they have passed through their end-usage as a consumer item, including used corrugated boxes, old newspapers, old magazines, mixed waste paper, tabulating cards and used cordage; and all paper, paperboard and fibrous wastes that enter and are collected from municipal solid waste.”

Postpress operations: Supplementary operations to printing such as binding, finishing and distribution. The demands of finishing and postpress operations include folding, die-cutting, cutting, trimming, scoring, stitching, gluing and perforating.

Precommercial thinning: Stand-tending method, performed relatively early in the rotation, in which a stand is thinned by cutting down poor-quality trees and unwanted species (usually left in the forest). Precommercial thinning is done to reduce competition among trees for soil moisture, nutrients, light and space.

Preconsumer fiber: Defined by the U.S. Environmental Protection Agency as “materials generated during any step of production of a product, and that have been recovered from or otherwise diverted from the solid waste stream for the purpose of recycling, but does not include those scrap materials, virgin content of a material or by-products generated from, and commonly used within, an original manufacturing process.” For paper recycling, includes trim from converting envelopes, paper plates and cups, boxes and cartons and printing runs, and over-issue publications and forms.

Prescribed burning: Managed application of low-intensity fire in a carefully prescribed area. Prescribed burning is done to control hardwoods and other brush in managed pine forests, including plantations.

Press: Sets of rolls through which the paper web passes during manufacture. This process occurs either to remove water from the web in the wet press; to smooth and level the sheet's surface in the smoothing press; or to apply surface treatments to the sheet in the size press.

Pressure sensitive adhesives: Adhesives that are activated by applying pressure; usually used in the manufacture of labels and tapes. According to deinking experts, the most difficult contaminants to remove during deinking are the polymeric adhesives used as pressure sensitive adhesives and hot-melt glues.

Pressure sensitive labels: "Peel and stick" labels.

Print quality: Paper properties that determine the quality of appearance of the sheet after printing, as judged by contrast, resolution of the printed image, type and reproduction of halftones.

Print resolution: The appearance of color, halftones, line art and type on the sheet.

Printability: A paper's ink receptivity, uniformity, smoothness, compressibility and opacity.

Printing and writing papers: Broad category defined by the American Forest & Paper Association to include coated and uncoated freesheet and coated and uncoated groundwood grades; it excludes newsprint.

psi: Pounds pressure per square inch.

Publication papers: Paper grades used in magazines, books, catalogs, direct mail, annual reports, brochures, advertising pieces and other publication and commercial printing products.

Pulp: Cellulose fiber material, produced by chemical or mechanical means, from which paper and paperboard are manufactured. Sources of cellulose fiber include wood, cotton, straw, jute, bagasse, bamboo, hemp and reeds.

Pulpwood: Roundwood products, whole-tree chips, or wood residues that are used for the production of wood pulp.

Purchased energy consumption: Amount of purchased electricity and fossil fuels that mills use to run the equipment and to generate process steam. Cogeneration and more effecient combustion of lignin and other wood waste decreases the purchased energy consumption of the mill.

Rag paper: Paper made from cotton cuttings and linters; usually referred to as cotton-fiber paper.

Reactivity: Propensity of a sheet to gain and lose moisture when subjected to heat and/or changes in humidity.

Ream: 500 sheets of printing paper.

Recovered paper: Paper collected for the purposes of recycling.

Recycling: The process by which materials that would otherwise be destined for disposal are used to manufacture products. In basic terms, successful recycling requires that four things happen in sequence: (1) collection of recyclable materials; (2) intermediate processing to remove contaminants and to sort and compact materials for shipment; (3) manufacturing of new products; and (4) the purchase of products containing recovered materials by business and individual consumers.

Recycled-content paper: Paper that contains some recycled fiber.

Reel: Roll onto which paper is wound at the end of the paper machine.

Refiner mechanical pulp (RMP): Mechanical pulp made using a single-disk or double-disk refiner.

Regeneration: Establishment and early development of new tree seedlings. In unmanaged forests, regeneration takes place on a variety of scales — from individual trees to large areas of forest leveled by large-scale natural disturbance, such as wildfire. In managed forests, regeneration may be natural or "artificial" (performed through planting), and may occur at the level of an individual tree or small group of trees (following selection harvests in uneven-aged silviculture) or at the level of a stand (following clearcutting or other harvesting methods in even-aged silviculture).

Reprographic paper: Reprographic paper is multi-purpose paper designed for use in copy machines, laser printers, ink-jet printers and plain paper faxes. It is often referred to as *dual purpose* paper.

Residues: Bark and woody materials that are generated in primary wood-using mills when roundwood products are converted to other products. Examples are slabs, edgings, trimmings, miscuts, sawdust, shavings, veneer cores and clippings and pulp screenings; includes mill residues from bark and wood (both coarse and fine material), but excludes logging residues, which are included in roundwood.

Resource Conservation Recovery Act (RCRA): Federal hazardous and solid waste statute enacted in 1976 and amended several times, most significantly in the Hazardous and Solid Waste Amendments of 1984. Codified as Title 42 of the United States Code, Sections 6901 - 6987.

Rigidity: Stiffness; resistance to bending.

Riparian zone: See streamside management zone.

Rotation: In even-aged silviculture, the period of time between harvests. (Related terms: *rotation age*, referring to the age at which a stand is harvested, and *rotation length*, the length in years of the rotation.) Where production of solid wood or fiber is the management objective, the rotation age is generally timed to maximize the net economic return from the stand, allowing for considerations such as mill supply and demand. Rotation ages for pulpwood management are significantly shorter than for sawtimber (although pulpwood may also be harvested from forests managed on sawtimber rotations, in the form of logs too small or otherwise unsuitable for use as sawtimber). Rotation lengths vary depending on tree species, desired product, site quality and region.

Roundwood products: Logs, bolts and other round timber generated from harvesting trees for industrial or consumer use. In this volume, which follows the conventions of the USDA Forest Service and other federal agencies, roundwood includes so-called logging residues, which are wood chips made from wood that would otherwise be left on-site.

Runability: Paper properties that affect the ability of the paper to run in office equipment and printing presses.

Sawtimber: Classification of timber inventory that is composed of sawlog-sized trees of commercial species. Sawlogs are logs meeting minimum standards of diameter, length and defect; they include logs at least 8 feet long that are sound and straight, and with a minimum diameter inside the bark of 6” for softwoods and 8” for hardwoods; other combinations of size and defect may be specified by regional standards.

SBS: Solid bleached sulfate boxboard.

Scoring: Creasing by mechanical means to facilitate folding and guard against cracking of the paper or board.

Secondary fiber: Recovered paper.

Secondary treatment: Wastewater treatment systems that use microorganisms to convert the dissolved organic waste in the effluent into a more harmless form. Although primarily designed to remove BOD, secondary treatment also reduces the loading of COD and AOX.

Seconds: Paper that is damaged or has imperfections.

Sedimentation: Deposition of eroded soil into streams or bodies of water. Depending on stream flow and other site conditions, deposited sediment can settle on the stream floor, burying gravels in the streambed and degrading spawning habitat for fish. Elevated sediment concentrations in water can also harm filter-feeding organisms and may interfere with the functioning of the gills of some organisms.

Seed-tree method: Even-aged harvesting/regeneration method in which all of the merchantable timber in a stand is removed in one cutting, except for a limited number of seed trees left singly or in small groups as a seed source to facilitate natural regeneration. These trees typically are harvested after the stand has successfully regenerated.

Selection method: Harvesting/regeneration method used in uneven-aged silviculture in which mature trees are removed, individually (single-tree selection) or in small groups (group selection), from a given tract of forestland over regular intervals of time.

Semi-chemical pulp: Pulp made by a combination of mechanical and chemical processes; typically used to make corrugating medium.

Shade-intolerant species: Tree species (or, more broadly, plant species) that are generally outcompeted in shaded conditions but grow vigorously in full sunlight. Many commercially valuable species, such as loblolly pine and Douglas fir, are shade-intolerant. Because of their preference for light, shade-intolerant species are usually managed using even-aged systems.

Shearing: Site preparation method that involves the cutting of brush, trees or other vegetation at ground level using tractors equipped with angles or V-shaped cutting blades.

Sheet: Term applied to a single sheet, a paper grade or a description of the paper; i.e., coated, uncoated, or offset.

Sheeting: Process of cutting a roll of paper or board into sheets.

Shelterwood method: Removal of the mature timber from a stand in a series of cuttings (usually two) that extend over a relatively short portion of the rotation, in order to encourage the establishment of essentially even-aged reproduction under the shelter of a partial canopy. In *irregular shelterwood*, the period between the first and second cutting is extended to allow the development of a two-aged stand.

Shrinkage: Decrease in dimensions of a paper sheet; weight loss between amount of pulp used and paper produced.

Silviculture: The art and science of establishing, tending, protecting and harvesting a stand of trees.

Single-tree selection: Method of harvesting in which individual merchantable trees are removed periodically. Natural regeneration is typically relied on to fill in the resulting gaps.

Site preparation: Silvicultural activity to remove unwanted vegetation and other material, and to cultivate or prepare the soil for regeneration.

Size press: Press section of the paper machine, near the end, where sizing agents are added.

Sizing: Process that enables paper to resist penetration by fluids. Sizing can also provide better surface properties and improve certain physical properties of a sheet. The papermaker generally applies either surface or internal sizing, which can be applied as sole treatments or in combination.

Skid trail: Temporary, non-structural pathway over forest soil used to drag felled trees or logs to the landing.

Skidding: Short-distance moving of logs or felled trees from the stump to a point of loading.

Slash: See logging debris.

Slice: Device that controls the flow of pulp from the headbox of a fourdrinier paper machine.

Slurry: Watery suspension of fibers or pigment used in papermaking or coating, respectively.

Smoothness: May be measured by the degree of resistance that the paper provides to air moving across its surface. Smoothness influences print quality, ink holdout and transport of paper through machine. The degree of smoothness of an uncoated grade of paper is determined by fiber species, fiber length and finishing processes such as surface sizing and calendering.

Snags: Dead but still standing trees. Snags are important habitat for many species of wildlife: an abundance of invertebrates; birds that construct or nest in cavities and/or feed on the invertebrates; and small mammals that live in the cavities.

Sodium hypochlorite: Bleaching chemical produced by mixing sodium hydroxide and elemental chlorine. Mills are eliminating this chemical from bleaching processes because it produces chloroform.

Softwood: Coniferous, usually evergreen, tree that has needles or scale-like leaves; e.g., pine, Douglas fir and spruce.

Solid board: Paperboard made of only one type of furnish.

Sorted office paper: Paper typically found in offices; may contain a small percentage of groundwood papers such as computer printout and fax paper, but is free of unbleached fiber such as corrugated boxes.

Solid chipboard: Board made entirely from wastepaper with no liner or coating: Produced on a cylinder machine.

Species diversity: Measure of the abundance and relative frequency of species in a specified area. Species diversity is often used with respect to animal or plant populations in a single stand, but can also be thought of on regional and global scales. For the purposes of biodiversity conservation, spatial scales of species diversity are hierarchical: global diversity is a higher conservation priority than regional diversity, and both are more important than local or stand-level diversity.

Stand: Contiguous group of trees sufficiently uniform in species composition, arrangement of age classes and condition to be a homogenous and distinguishable unit; also the area defined by the extent of those trees.

Starch: Sizing agent usually made from corn and potatoes; improves rigidity and finish by causing fibers to lie flat.

Stem-exclusion stage: The second stage of stand development in a forest, in which the forest canopy closes and the arrival (or *recruitment)* of new seedlings halts. Because a closed canopy limits the amount of light reaching the forest floor, understory growth is limited, stand vegetation is simpler and species diversity tends to be lower than in other stages.

Stickies: Particles of plastic, adhesives or naturally tacky materials (e.g., pitch from pine trees) that are embedded in the paper sheet or attached to the forming machine; caused by non-soluble residual particles of hot-melt glues, adhesive labels and other contaminants present in secondary fiber.

Stiffness: Ability of paper to resist deformation under stress and to resist bending stress. It affects how well the paper performs in transport through press and office equipment and during converting. The properties of stiffness are determined by the basis weight and caliper of the paper, the type and quantity of fiber and filler used in the paper, and the degree of fiber bonding.

Stock: (1) Paper or board that is in inventory. (2) Paper or board used in the printing or converting process. (3) Fibrous mixture that is made into paper; also called furnish. (4) Wastepaper.

Stone groundwood (SGW) pulping: Process of pressing logs against a grindstone while a stream of water wets the stone and removes the pulp. This process has the highest yield (93 - 96%) of all pulping processes, but it also produces the weakest pulp.

Streamside management zone (SMZ): May also be called buffer strips or *riparian management areas*. Zone of forest along a forest stream where management practices that might affect water quality, fish or other aquatic resources are modified. Properly designed SMZs effectively filter and absorb sediments, maintain shade, protect aquatic and terrestrial riparian habitats, protect channels and streambanks and promote floodplain stability. State Best Management Practices generally recommend SMZs, although restrictions and key parameters (e.g., SMZ width) vary.

Strength: Generally three types of strength are measured: folding, tensile and tear. Strength is important so paper can run through machines without tearing and can withstand folding without cracking. A paper's strength is determined by interfiber bonding during sheet formation, fiber strength, the type of fibers and filler in the sheet, basis weight of the sheet and the degree of refining.

Stumpage: Trees “on the stump.” Landowners sell these trees to loggers for which they are paid a given price (*stumpage price*).

Succession: With respect to forest development, succession refers to the changes over time as a forest proceeds from one developmental stage to the next: thus early-successional stands describe stands in the years just after regeneration, while late-successional stands refer to stands in mature or old-growth forests.

Sulfate pulp: See kraft pulp.

Sulfite pulping: Pulp produced with sulfur dioxide and calcium, magnesium, ammonium or sodium bases. The pulp can be produced at different pH levels. The higher the pH, the stronger the pulp produced. At pH = 14, the strength of sulfite pulp equals that of kraft pulp.

Sulfur dioxide: (SO_2): Chemical compound produced when boilers burn fuel that contains sulfur. Of the fuels used in the paper industry, oil and coal generally contain the highest quantities of sulfur.

Supercalendering: Process that uses alternate metal and resilient rolls to produce a high finish paper separately from the papermaking machine. Supercalendered (SC) papers have been smoothed through an extra calendering phase during papermaking; have clay and other pigments that enhance appearance by adding brightness, smoothness, opacity, strength and bulk.

Surface strength: Cohesiveness of fibers on the surface of a paper.

Surface-sized: Term applied to paper to which a sizing agent has been applied when the paper web is partially dry. The purpose of surface sizing is to increase resistance to ink penetration.

Suspended solids: See total suspended solids.

Tack: In printing inks, the property of cohesion between particles. A tacky ink has high separation forces and can cause surface picking.

TAPPI: Technical Association of the Pulp and Paper Industry.

Tear strength: Indicator of the fiber length and the uniformity in refining and formation of a paper sheet. Tear strength is especially important to printers and lithographers. It is determined by a test that measures the average force in grams required to tear a single sheet of paper once the tear has been started.

Tensile strength: Defined as the maximum force required to break a paper strip of a given width under prescribed laboratory conditions; measured as the force (pounds per inch) per unit width of a sample that is tested to the point of rupture.

Text paper: General term applied to various grades of printing papers that are made specifically for books.

Thermomechanical pulp (TMP): Pulp produced from wood chips that have been exposed under pressure to superheated steam. The heat softens the lignin, which allows fiber separation with less damage than in purely mechanical pulping. TMP processes use a refiner that consists of one or two rotating serrated disks to separate the fiber in wood chips. TMP processes reduce the energy requirement of the refining process and increase the strength of the pulp. Typical pulp yields range from 90% to 95%.

Tip fees: Solid waste disposal charges; a refuse collection truck empties or "tips" its load at a landfill, transfer station or incinerator.

Tissue paper: Paper category characterized by extreme lightness and transparency; basis weight is less than 18 lbs. Tissue paper is used to make napkins, bathroom tissue, paper towels, etc.

Titanium dioxide: Chemical compound used as loading or coating material to increase the whiteness and brightness of a paper sheet and enhance its opacity.

Topliner: Outermost layer of multi-ply paperboard.

Total energy consumption: Energy, including electricity and all forms of fuels, consumed to produce a ton of pulp or paper.

Totally chlorine-free (TCF): Bleaching process that uses no chlorine-based chemicals.

Total reduced sulfur compounds (TRS): Mix of organic compounds that cause the odor associated with kraft pulp mills. These compounds include hydrogen sulfide, dimethyl sulfide, dimethyl disulfide and methyl mercaptan.

Total suspended solids (TSS): Amount of solids in the effluent. They can eventually settle on the bottom of a mill's receiving water and affect the habitat of bottom-living organisms. Well-operated treatment systems remove most of these solids. Concern remains, however, because heavy metals, dioxins and other unchlorinated compounds can be adsorbed onto the remaining suspended solids.

Toxic equivalence (TEQ): The EPA uses toxic equivalence factors (TEFs) to estimate the relative toxicity of different members of the dioxin and furan families, because they produce similar toxic effects, but at different doses. E.g., TCDD is the most toxic member of the dioxin and furan family and is assigned a toxic equivalence factor of 1.0, while the less toxic TCDF is assigned a toxic equivalence factor of 0.10. Using these factors, the sum of the toxicity of one gram of TCDD and one gram of TCDF would be equal to 1.1 grams TEQ of TCDD.

Twin-wire machine: Paper machine in which pulp slurry is injected between two forming wires, and water is drained from both sides of the paper web.

Two-sidedness: Visual differences between the top (or felt) side of a paper sheet and the bottom (or wire) side.

Unbleached: Paper or paperboard made from natural colored pulp that has not been brightened.

Uncoated freesheet: Bleached uncoated printing and writing papers containing not more than 10% groundwood or other mechanical pulp.

Uncoated: Paper or board that has not been coated. Uncoated paper grades are made in a variety of finishes.

Uncoated groundwood papers: Papers containing more than 10% mechanical pulp (stone groundwood, refiner or thermo-mechanical) in their furnish, excluding newsprint.

Understory: Level of vegetation between the ground and the forest canopy, or overstory.

Uneven-aged management: Class of silvicultural systems that maintain several age classes of trees simultaneously in a forest. In a managed uneven-aged forest, the objective of management is to create and maintain a certain distribution of trees: many more trees are in small size (age) classes than in large ones. The selection method, either single-tree or group selection, is the harvesting/regeneration method used in uneven-aged management.

Volatile organic compounds (VOCs): Broad class of organic gases, such as vapors from solvents and gasoline that react with nitrogen oxides in the atmosphere to form low-level atmospheric ozone.

Washing deinking: Process of removing ink by dewatering pulp.

Web break: Break in a roll of paper while it is on the machine during manufacturing or on the printing press during production.

Web: Continuous sheet of paper produced and rolled up at full width on the paper machine.

Wet end: Beginning of the paper machine where the headbox, forming wire and press section are located.

Wet-strength paper: Paper that retains 15% or more of its dry tensile strength when wet.

Wetlands: Areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include *swamps*, *marshes*, *bogs* and similar areas. (This definition is taken verbatim from regulations of the Environmental Protection Agency, published in the *Code of Federal Regulations*, Volume 40, Part 230.3(t). The U.S. Army Corps of Engineers, which shares authority over wetlands with EPA, uses the identical definition. *Code of Federal Regulations*, Volume 33, Part 323.2 (c).)

Whole-tree harvesting: Practice of removing entire trees at harvest, including tops, limbs, branches, twigs and leaves. In many cases, these trees are chipped whole on site to produce *whole-tree chips*.

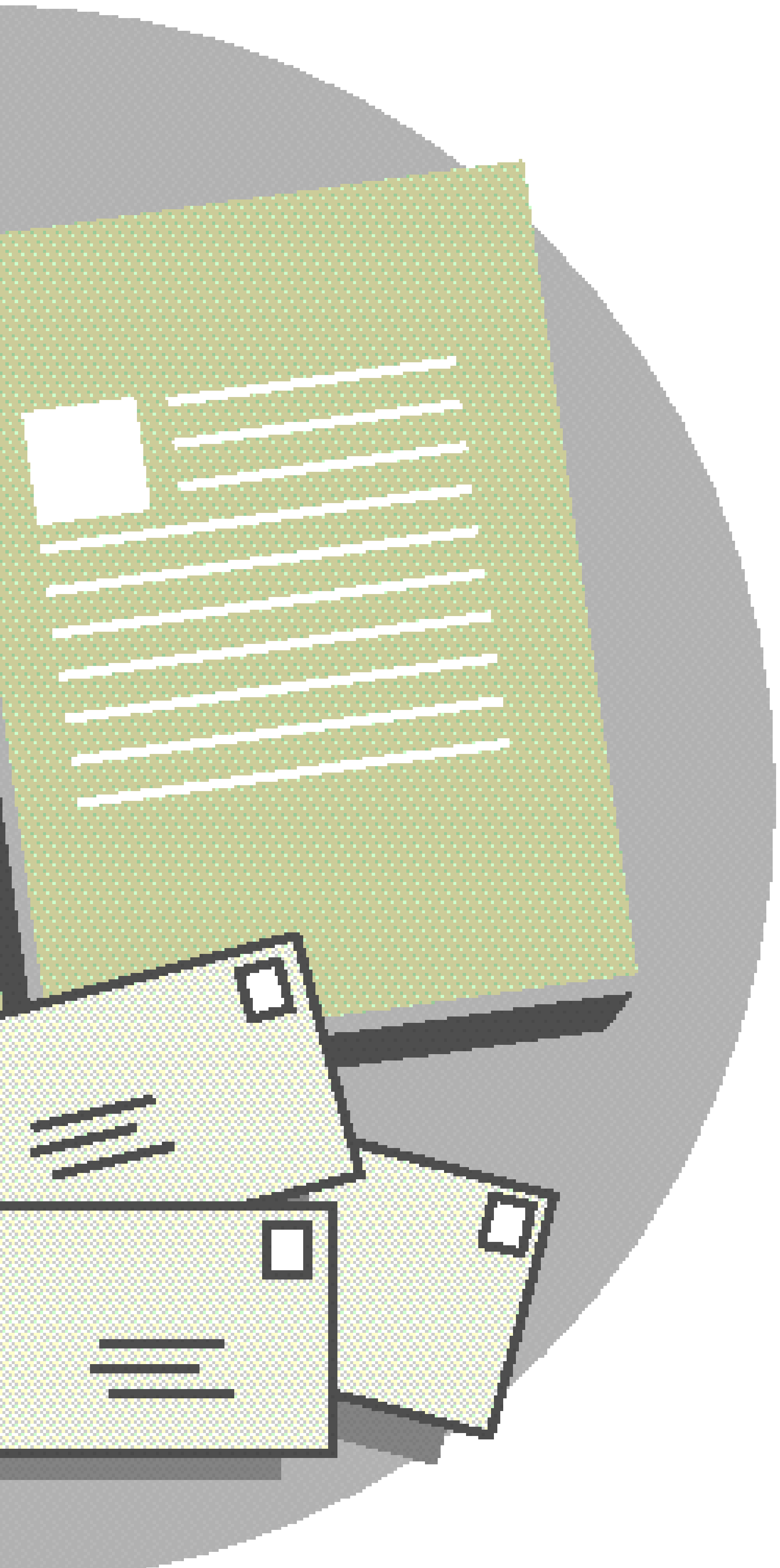
Window envelopes: Envelopes with openings that show the mailing address; openings are either open or covered with plastic or glassine.

Windrowing: Silvicultural activity, associated with intensive site preparation, that removes logging debris and unmerchantable woody vegetation into rows or piles to decompose or be burned.

Wire: The bottom side of a sheet of paper is the side that has had contact with the wire of the paper machine during manufacture. The wire is a synthetic (often polyester), copper or bronze screen that transports the water and fiber suspension from the wet end to the dry end of a paper machine.

Xerography: Copying process that uses a selenium surface and electrostatic forces to form an image, i.e. “photocopying”.

Yarding: Method of transport from harvest area to storage landing.



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