

**MARKET STUDY OF
MOLECULAR CHLORINE-
FREE AND TOTALLY
CHLORINE-FREE
BLEACHED PAPER**

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TABLE OF CONTENTS

GLOSSARY	i
EXECUTIVE SUMMARY	iii
CHAPTER 1: INTRODUCTION	1-1
1.1 Background	1-1
1.2 Areas for Future Research	1-3
1.3 Overview of the Report	1-3
CHAPTER 2: BLEACHED PULP AND PAPER MARKETS	2-1
2.1 Introduction to Pulp and Paper Markets	2-1
2.2 Major Paper Product Categories	2-4
2.3 Major Paperboard Product Grades	2-13
2.4 Overview of the Major Pulp, Paper, and Paperboard Producers	2-22
2.5 Bleached Paper Products	2-25
2.6 Conclusions	2-44
CHAPTER 3: CHARACTERISTICS OF BLEACHED PAPER	3-1
3.1 Factors Affecting Paper Attributes	3-1
3.2 Summary	3-10
CHAPTER 4: CHARACTERISTICS OF MARKETS FOR UNBLEACHED AND ALTERNATIVELY BLEACHED PRODUCTS	4-1
4.1 Commercially Available Unbleached or Alternatively Bleached Paper Products	4-1
4.2 Paper Market: Consumer Groups	4-23
4.3 Paper Market: Unbleached versus Alternatively Bleached	4-24
4.4 The European Market	4-26
4.5 Inhibiting Factors Slowing Conversion from Molecular Chlorine Bleaching	4-29
4.6 Future Trends	4-34
APPENDIX 2.A BLEACHED AND UNBLEACHED PULP PRODUCTION VOLUMES	2A-1
APPENDIX 2.B COMPREHENSIVE LISTING OF ALL MILL OUTPUTS FOR ALL PAPER AND PAPERBOARD GRADES	2B-1
APPENDIX 2.C MILLS AND FIRMS PRODUCING PRODUCTS WITH HIGH OR MEDIUM BLEACHED PULP CONTENT	2C-1
APPENDIX 2.D BUREAU OF CENSUS DATA	2D-1
APPENDIX 3.A OVERVIEW OF THE PULPING PROCESS	3A-1

Note: Appendices' numbers correspond to chapters in which they are referenced.

GLOSSARY

The following definitions referring to bleaching processes have been adopted for this report:

Alternatively Bleached - Variant term for molecular chlorine-free or totally chlorine-free bleached paper (see below).

Bleaching - The process of chemically treating fibers to reduce or remove coloring matter so that the pulp is improved in terms of whiteness or brightness.

Chlorine Bleached - Bleached with molecular chlorine (Cl_2) or a chlorine compound.

Molecular Chlorine-free (MCF) - Bleached without the use of molecular chlorine (Cl_2) (e.g., bleached with sodium hypochlorite, chlorine dioxide, oxygen, ozone, and/or hydrogen peroxide) - also referred to as Elemental Chlorine-free (ECF).

Totally Chlorine-free (TCF) - Bleached without the use of molecular chlorine (Cl_2) and chlorine compounds (e.g., bleached with hydrogen peroxide, ozone, and/or oxygen).

Unbleached - Produced without being treated with bleaching agents.

Unrebleached - Produced from recycled paper feedstock without the use of additional bleach. Feedstock may or may not have been bleached.

EXECUTIVE SUMMARY

The investigation summarized in this report sought to identify opportunities for reducing the amounts of chlorinated organics released to the environment as a result of the production of paper and paperboard. The reductions could result from changes in:

- the processes used to produce pulp and paper, and
- the demand for chlorine bleached products.

This report examines market demand for molecular chlorine-free (MCF) and totally chlorine-free (TCF) bleached paper products as well as paper products that are unbleached and bleached with reduced amounts of chlorine. The report also examines the impact of chlorine bleaching on the quality of the product, as well as some of the technological problems of bleaching without the use of chlorine. By examining both the technical and the market considerations, this analysis provides a foundation for exploring the question of where and to what degree the use of chlorinated organics by the pulp and paper industry might be reduced.

The purpose of this report is to provide background information for the Pulp and Paper Cluster, a workgroup established by EPA to coordinate the activities of various EPA offices affecting the pulp and paper industry. Originally written in late 1990 and early 1991, the report was sent out for public review and comment. Responses to the comments that fell within the scope of this report were incorporated. This report summarizes readily available and easily obtainable information in the expectation that greater detail would be forthcoming as a result of the Office of Water's development of effluent guidelines and the Office of Air's development of maximum achievable control technology (MACT) standards for the pulp and paper industry.

Major Findings

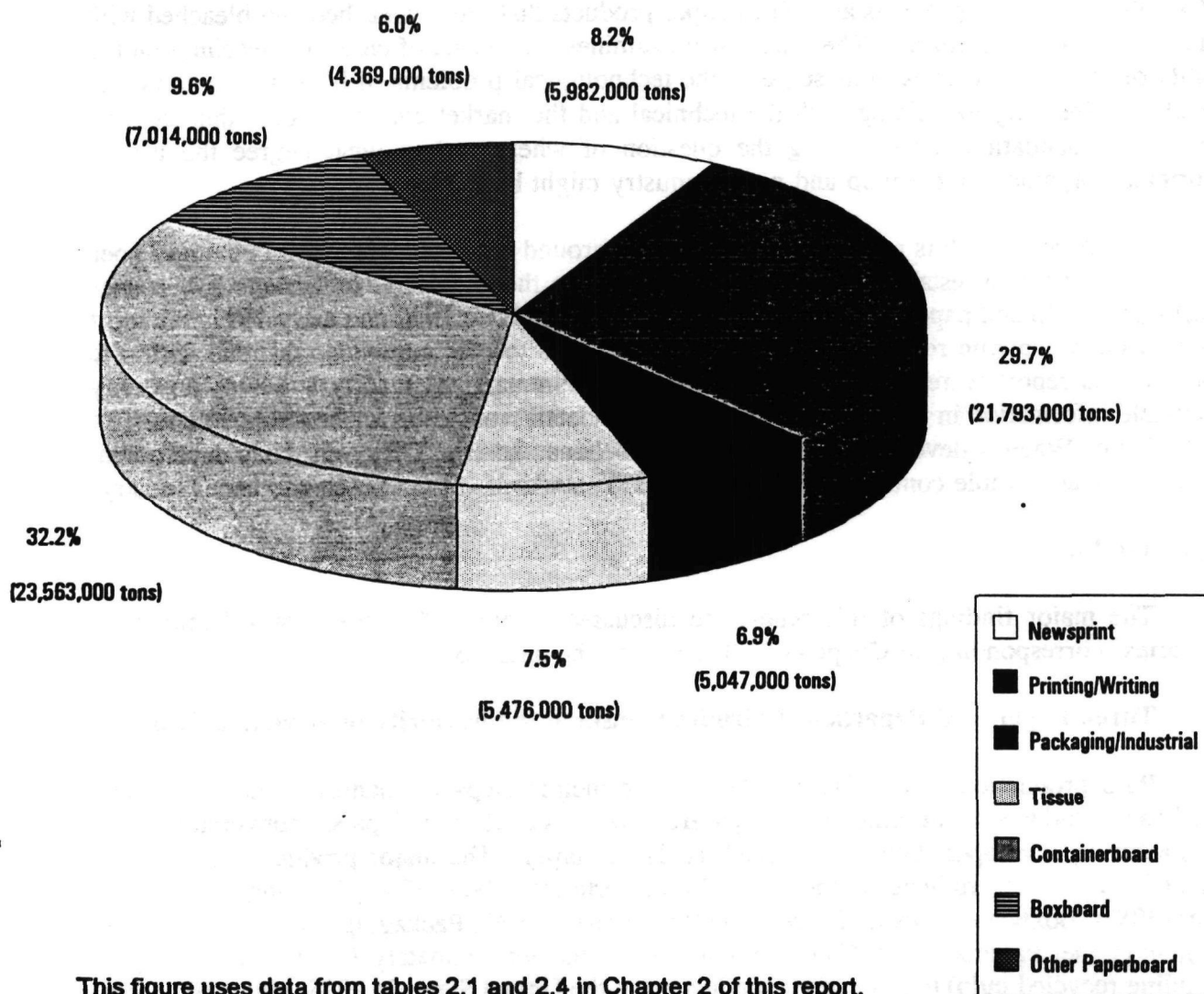
The major findings of this report are discussed below. They are grouped into three categories, corresponding to Chapters 2, 3, and 4 in the analysis.

Three Paper and Paperboard Grades Consume the Majority of Bleached Pulp

Pulp production is the first of the three principle steps in manufacturing paper and paperboard products. The other two steps are paper production and paper conversion (e.g., manufacturing envelopes, tablets, gummed labels and tape). The major product categories (in terms of quantity of products shipped) are: Containerboard (about 32%), Printing and Writing Paper (30%), Boxboard (10%), Newsprint (8%), Tissue (7.5%), Packaging and Industrial Paper (7%), and Other Paperboards (6%) (see Figure 1). Of the approximately 71 million tons of pulp (including recycled pulp) used in paper production in the United States in 1988, about 30 percent was bleached, although not all with chlorine. According to the 1989 Lockwood-Post Directory, 74 of the 104 mills that used chlorine bleaching were controlled by the 20 largest paper companies (see Figure 2).

Figure 1

U.S. Paper Products Shipments
(Percentage of Total U.S. Paper and Paperboard Production by Weight, 1988)*



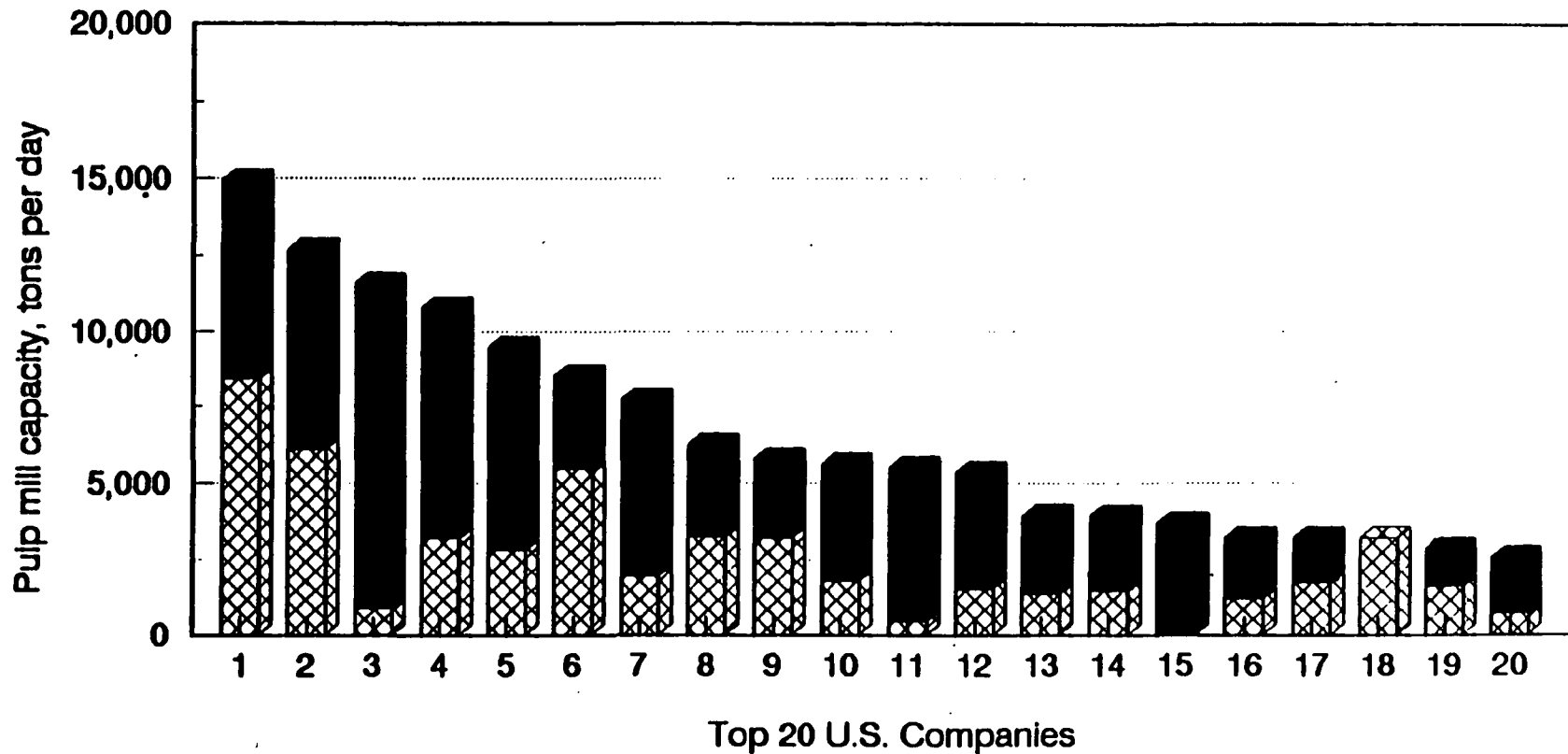
This figure uses data from tables 2.1 and 2.4 in Chapter 2 of this report.

Source: 1989 API Statistics of Paper, Paperboard, and Wood Pulp.

*Percentages do not sum to 100.0% due to rounding.

Figure 2

Bleached Kraft Mill Capacity and Total Mill Capacity for Top 20 U.S. Producers, 1988
(Tons per day)



This figure uses data from table 2.8 in Chapter 2 of this report.
Source: Lockwood-Post 1989, and ERG industry estimates.

Whether or not pulp is bleached largely depends on the specific paper product for which it will be used. The analysis, therefore, categorized paper and paperboard product grades by the amount of bleached pulp they used. The total amount of bleached pulp used for a particular grade depends on both the total amount of the grade produced and the percentage of bleached pulp included. While both recycled fibers and virgin pulp can be bleached, this analysis identifies products that compel the initial use of bleach and therefore focuses on the use of bleached virgin fibers.

Three grade segments combined use over 85 percent of the bleached virgin kraft pulp (see Figure 2.5, Chapter 2):

- Printing and writing papers (58%),
- Solid bleached paperboard (mostly boxboard) (16%),
- Tissue (13%).

Future efforts to reduce or eliminate the use of chlorine-based bleaching chemicals may be most usefully focused on these three grade segments, with particular focus on printing and writing papers.

Technological Constraints on Reducing Chlorine Use Are Decreasing

No simple relationship exists between the use of chlorine and the type of paper products produced. For this reason, it is not easy to determine whether or not chlorine use is necessary in paper production. In addition, bleaching technologies are changing rapidly, reducing the amount of chlorine required to produce comparable products.

From a technical perspective, it is possible to make printing/writing paper, tissue, and solid bleached paperboard without molecular chlorine (Cl_2). Many products can also be successfully produced by a TCF sequence. The highest brightness levels (GE 90 and above), however, currently require molecular chlorine bleaching. The amount of bleaching and the bleaching chemicals are a function of both the type of pulping process and the intended end-use of the pulp. For example, mechanical pulps are usually unbleached and, when bleached, usually do not use chlorine. Chemical pulps, especially kraft, are usually bleached with chlorine. Several alternatives to chlorine are currently being used in place of, or in conjunction with, chlorine. These alternatives, however, can have the following drawbacks (Clement Associates, 1989):

- more costly (e.g., chlorine dioxide, hydrogen peroxide, and oxygen),
- reduced pulp yield (e.g., ozone),
- reduced pulp strength (e.g., oxygen),
- potential sources of other pollutants (e.g., hypochlorite, which may produce chloroform).

An EPA report (U.S. EPA, 1990) details the range of available and emerging technologies for the control of chlorinated organics in the pulp and paper industry.¹ As these alternatives develop, some may prove to be more successful than currently available alternatives in terms of both effectiveness and cost. Many of the new technologies, however, continue to require some use of chlorine.

Information collected by EPA in the 1990 Section 308 National Census indicates that many pulp mills have recently taken or plan to take actions to reduce the amount of polychlorinated dioxins (PCCDs) and furans (PCDFs) generated by chlorine bleaching of pulp (U.S. EPA, 1991). Based on a preliminary summary of industry response to the Census, 64 mills (out of the 105 mills that perform chlorine bleaching of chemically produced pulps) indicated that they have made substantial changes in their bleach plant operations since 1988.² The pulping and bleaching technologies used at a mill depend to some degree on site-specific parameters. According to the EPA preliminary summary, significant trends in bleach plant operations are:

- Elimination of defoamers with dioxin precursors;
- Increased substitution of chlorine dioxide (ClO₂) for chlorine in the chlorination stage of the bleaching process;
- Modernization and improvement in controlling chlorine bleaching;
- Increased use of peroxide to enhance the extraction stages of the bleaching process;

¹Pulping technologies that reduce the use of chlorine include: extended delignification, oxygen delignification, polysulfide cooking, improved pulp washing, pretreatment with nitrogen dioxide, demethylation, anthraquinone catalysis, ozone delignification, and peroxide delignification. Bleaching technologies that reduce chlorine use include: chlorine dioxide substitution, oxygen extraction, peroxide extraction, MONOX-L substitution, control of chemical dosage, improved mixing, split chlorine addition/pH control, monitoring of chlorine multiple, slc extraction process, and closed cycle technology.

²The status of chlorine bleaching in 1988 and 1990 was determined from two EPA studies. In 1988, the EPA and the U.S. paper industry characterized the practices of U.S. mills that practiced chlorine bleaching of chemically produced pulps. This study is commonly called "The 104 Mill Study" (although it was later revised to include 105 mills). In 1990, EPA conducted a national census of pulp, paper, and paperboard manufacturing facilities under the authority of Section 308 of the Clean Water Act (referred to in this report as "the Section 308 National Census"). Only a preliminary summary of industry's response to the Census was available for this report.

- Anticipated increase in the number of mills using oxygen delignification;
- Anticipated decrease in the use of hypochlorite in bleaching and extraction stages; and
- Anticipated expansion of chlorine dioxide generation capacity, currently a significant factor inhibiting chlorine reduction, at 30 percent of facilities.

The number of mills reporting current and planned activities to reduce their use of chlorine in the bleaching process is summarized in Table 1. "Current" activities include those implemented after July 1988 and prior to December 1989. "Planned" activities include those reported in 1990 and those planned (generally January 1990 through December 1993, but a few as late as November 1997). The number of mills represented in Table 1 exceeds the total of 64 mills reporting changes because many mills are implementing several chlorine reduction activities.

The current and planned chlorine reduction activities listed demonstrate a continuing effort by industry to implement process modifications that: (1) increase chlorine dioxide substitution, and (2) increase peroxide use. The table also indicates an anticipated increase in the number of mills that will use oxygen delignification. Nearly one third of the mills will be replacing or updating their bleach lines to include more efficient chemical addition and mixing, better chemical use controls and flow meters, and improved bleach plant washing.

According to the preliminary summary, process changes to reduce formation of PCDDs and PCDFs have been implemented at mills producing a wide variety of pulp and paper products. The industry has placed major emphasis on those mills producing bleached pulp used in food grade and personal care products. While process changes have also been implemented at many market pulp bleached kraft mills (e.g., those producing bleached pulp for sale on the open market, or for sale overseas), such changes have not been uniformly made across that segment of the industry.

One very recent development in industry bleaching processes, that was not reflected in the Section 308 National Census, concerns the plans for a Louisiana-Pacific Corporation mill in Samoa, California, to convert its operations to TCF production. This conversion plan, which will be completed in 1995, was developed by Louisiana-Pacific in concert with EPA, the Department of Justice, the State of California, and the Surfriders Foundation. The plan formed the basis of a modified consent decree signed by these parties. Once the mill is converted, it will be the first U.S. facility completely dedicated to production of TCF pulp.

Table 1
Current and Planned Activities to Reduce Chlorine

Chlorine Reduction Activity	Number of Mills	
	Current	Planned
TCF Pulp Production	0	1
Implement/Increase Chlorine Dioxide Substitution	33	39
General Bleach Plant Replacement/Modernization/ Modification	17	36
Improve Brownstock Washing	11	21
Install Oxygen Delignification	8	17
Implement Hydrogen Peroxide Bleaching/Extraction	15	16
Eliminate/Reduce Use of OCl	8	12
Implement O ₂ Enhanced Extraction	5	7
Eliminate Dioxin Precursor Defoamers	7	8
Use Extended Delignification	2	3
Source: 1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities: Preliminary Summary Report of Questionnaire Responses for Mills that Bleach Chemical Pulps, Revised October 31, 1991, Commodities Branch, Engineering and Analysis Division, Office of Science and Technology, Office of Water, U.S. EPA. Table 4.		

Markets for Molecular Chlorine-free (MCF) Products are Developing

As of early 1992, a wide variety of unbleached or alternatively bleached paper products were available in the U.S. market, and many were in the categories of paper that have traditionally been chlorine bleached. Based on information assembled about these products, several conclusions can be drawn:

- There are unbleached or alternatively bleached products in each of the three paper categories currently using large amounts of bleached virgin kraft pulp.
- These products are being produced domestically, as well as in Canada and Europe.
- Reduced molecular chlorine use in pulp bleaching is being achieved by:
 - Using recycled fibers without rebleaching,

- Using recycled fibers and bleaching with reduced amounts of chemicals,
- Bleaching with a chlorine compound (e.g. sodium hypochlorite); and
- Bleaching with a chlorine alternative (e.g. hydrogen peroxide, oxygen, ozone).

Paper markets can usefully be divided in terms of two main consumer types: personal and commercial. Both markets have a group who are particularly concerned about, or see a competitive advantage from, protecting the environment. These groups are actively seeking and are willing to pay a premium for TCF paper. The majority of purchasers, however, do not appear to be making purchasing decisions based on the issue of chlorine.

There is a distinct difference between the demand for unbleached and alternatively bleached paper products. While some environmental and non-profit groups will only buy unbleached paper, paper products bleached with an alternative process have a much wider appeal to the general public.

Both in terms of production and market acceptance, alternatively bleached and unbleached paper is much more common in Europe than in the United States. This is particularly true in Germany (a country that imports large amount of pulp) and Sweden (a country that exports large amounts of pulp).

While the pulp and paper industry has made strides in reducing chlorine usage, several technological as well as financial constraints limit the amount and rate of change. Since many mills are substituting chlorine compounds for molecular chlorine, the potential environmental trade-offs of these substitutes should be examined to assure industry and the public that the appropriate changes are being made, and to avoid potentially more costly changes in the future.

Executive Summary References

Clement Associates, Inc., (1989). *"Dioxin Production in the Pulp/Paper Industry, Revised, Draft Report"*, Prepared for the Regulatory Impacts Branch, Office of Toxics Substances, U.S. EPA. October 31.

U.S. EPA, (1990). *"Summary of Technologies for the Control and Reduction of Chlorinated Organics from the Bleaching Chemical Pulping Subcategories of the Pulp and Paper Industry"*. April 27.

U.S. EPA, (1991). *"1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities: Preliminary Summary Report of Questionnaire Responses for Mills that Bleach Chemical Pulps"*. Office of Science and Technology, Office of Water. October 31.

CHAPTER 1: INTRODUCTION

This document is a revised version of a February 1991 draft U.S. Environmental Protection Agency report entitled *Unbleached and Non/Low-Chlorine Bleached Paper Market Study*. The revisions were made in response to comments from representatives of the pulp and paper industry and environmental groups. While this revised report includes some new information, changes concentrated on clarifying the presentation, not on collecting and presenting additional data. In particular, the Executive Summary and Chapters 1 and 4 were revised. Chapter 2 and 3 were not revised since they serve the purpose of this report and provide a background to pulping and bleaching technology.

This chapter describes the circumstance under which the study was originally undertaken and the purpose of the report. Definitions for terms used in the study are provided in a glossary at the beginning of the report. This chapter ends with a section suggesting areas for additional research that were outside the scope of this project.

1.1 Background

During the summer and fall of 1990 the EPA conducted a review of readily available sources of information on alternative approaches to reducing or eliminating the formation of chlorinated organics by the pulp and paper industry. Certain chlorinated organics are considered to be highly toxic based on laboratory animal experiments and have been linked to malignancies, birth defects, and physical deterioration in animals. While there is some controversy about the human health effects of chlorinated organics, the EPA has classified one isomer, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), as a "probable human carcinogen". Dioxins¹ can be formed during the manufacture of bleached wood pulp if chlorine is used as a bleaching agent. Studies by the paper industry and by government agencies in North America and Europe (including the U.S. EPA) have confirmed that detectable amounts of TCDD are produced and released into the environment at many bleached kraft pulp mills.

The investigation summarized in this report sought to identify opportunities to reduce the amounts of chlorinated organics released to the environment. This reduction would be a function of changes in (1) the processes used to produce pulp and paper, and (2) the demand for chlorine bleached products. The investigation also examined some of the technological, social, and economic impediments to these changes.

¹The term "dioxin" is commonly used to refer to a family of chemicals that includes polychlorinated dibenzo-para-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). There are 75 PCDD and 135 PCDF isomers. The majority of experiments, however, have dealt with the 2,3,7,8-tetra-chlorodibenzo-p-dioxin (TCDD) isomer.

This report was written to support the activities of the Pulp and Paper Cluster, a workgroup established by EPA to coordinate activities across the agency affecting the pulp and paper industry. The intent of the report was to review and summarize information readily available to help Agency staff prepare for cluster activities. The report was not intended to be all-inclusive or to present one particular viewpoint. It was intended to educate the staff about pulp and paper production and/or marketing.

Since completion of the draft report in the fall of 1990, additional information has become available, including that collected by the EPA's Offices of Water, Air, and Solid Waste as part of the development of effluent guidelines (Section 308 data), maximum achievable control (MACT) standards, and sludge disposal regulations. Some of the new data has been incorporated into this revision in response to comments. In August 1992, EPA sponsored an "International Symposium on Pollution Prevention in the Manufacture of Pulp and Paper". Over 300 people attended the symposium, which provided a forum to discuss new and emerging pulping and bleaching technologies and the demand for unbleached, molecular chlorine-free (MCF), and totally chlorine-free (TCF) paper products. The Agency intends to sponsor other projects and forums for assembling and disseminating information on these topics.

This report has three principle goals:

- An identification of the paper and paperboard grades in which the majority of chlorine-bleached pulp is used. Changes in the production of and demand for these grades are of primary concern to the EPA, since they will have the greatest effect on dioxin generation by the pulp and paper industry. The results of this identification analysis are presented in Chapter 2.
- An analysis of the attributes of paper and paperboard that are directly dependent upon chlorine bleaching and the ability of bleaching substitutes to meet specifications. This will illuminate some of the technical constraints on changing bleaching processes. Technical constraints and attributes of bleached paper and paperboard are discussed in Chapter 3.
- A characterization of markets that currently exist for unbleached and alternatively bleached paper products. This part of the analysis investigates the degree to which these unbleached and alternatively bleached products have been accepted by consumers, both commercial and individual. The findings are presented in Chapter 4.

1.2 Areas for Future Research

While providing an overview of the possibilities for and limitations to the production of unbleached and alternatively bleached paper products, the report also raises several questions outside the scope of this analysis. For example, the report does not attempt to analyze the economic impact of reduced chlorine use by the pulp and paper industry. This information would be critical in evaluating the effects of a proposed regulation. Furthermore, the size of the identified markets for unbleached and alternatively bleached paper were not quantified; the report indicates only whether a market is known to exist.

Useful research might also be conducted to determine the public's criteria for purchasing paper products. This research could help the EPA anticipate the public response to unbleached, as compared with alternatively bleached, products. The research could also be used to establish whiteness standards for printing/writing paper that meet individual and commercial needs. Research is also needed to evaluate risks associated with chlorinated organics other than 2,3,7,8-TCDD and 2,3,7,8-TCDF. The production of chlorinated organic pollutants resulting from the use of chlorine compounds in the bleaching process should also be examined.

Finally, increased paper recycling can reduce chlorine use by reusing bleached fibers. In particular, research to support the establishment of an infrastructure for the collection of high-grade office papers would be valuable.

1.3 Overview of the Report

In addition to this Introduction, the report contains three chapters. Chapter 2 provides an overview of the pulp and paper industry, including the number and size of mills, and defines product grades of interest for this analysis by estimating the amounts of bleached pulp used by each grade. Chapter 3 discusses the technical factors affecting the amount and type of bleaching undertaken, and relates these factors to product attributes. Chapter 4 identifies a variety of products currently available in unbleached and alternatively bleached forms in both North America and Europe. Based on literature reviews, anecdotal information gathered from interviews, and the results of consumer surveys previously undertaken, Chapter 4 examines the factors that encourage or impede the market for unbleached and alternatively bleached products.

CHAPTER 2: BLEACHED PULP AND PAPER MARKETS

This chapter presents an analysis of products made from bleached kraft pulps and the companies and mills which produce them. Bleached kraft pulp is produced by the sulfate bleaching process, and is used to manufacture a wide range of paper and paperboard products for consumer, commercial, and industrial use. The chapter has two main sections. The first section provides an overview of the pulp and paper market. The second section estimates the quantity of various grades of paper and paperboard that is bleached.

Two primary sources of information are used in this report. For data on product shipments, the American Paper Institute's (API, 1989) most recent statistical report was used. The report generally provides consistent data series for most product categories over the last 10-15 years. The other major source used is the Lockwood-Post's Directory of the Pulp, Paper, and Allied Trades (Lockwood-Post, 1989 and 1990). This source profiles establishments engaged in pulp and paper making and paper converting in the United States, and includes information on the types (and often volumes) of products produced and the processes utilized. Additional data from the Bureau of the Census (1989) was also used, particularly for presenting information on value of product shipments.

In addition to these published sources, this report develops original estimates of aggregate fiber content and pulp composition of major grades of paper and paperboard through discussions with industry observers and experts. These sources are discussed in the appropriate sections of the report.

2.1 Introduction to Pulp and Paper Markets

2.1.1 Industry Structure

The pulp and paper industry can be categorized into three primary segments, corresponding to the three basic operations in paper production:

1. **Pulp production** converts wood or other fibrous material into a liquid slurry suitable for paper manufacture. Wood is the primary fiber source for the pulp and paper industry; however, recycled fiber accounts for approximately one-fourth of all fiber converted to pulp. Some non-wood natural fibers, such as cotton, are also used for specialty papers.
2. **Paper production** converts pulp to one of several dozen grades of paper suitable for manufacture of finished paper products. Coating and some surface finishing operations may be part of the paper production process.

3. **Paper conversion** includes operations such as cutting, coating, folding, printing, and other finishing processes, and results in production of paper products for consumer, commercial, and industrial markets.

This analysis focuses on pulp and paper producers. Paper converters, which purchase paper from mills, are numerous and highly differentiated. An analysis of this segment of the industry is outside of the scope of this study. Further, it is expected that pulp mills and paper mills will be more greatly affected by changing bleaching processes than will converters.

The information presented in this section is derived primarily from self-reported industry statistics compiled in the 1989 Lockwood-Post's Directory of the Pulp, Paper, and Allied Trades (Lockwood-Post, 1989). This information, current through 1988, has not been independently verified. Of the potential sources of inaccuracy in these statistics, two should be noted specifically: (1) some firms did not provide capacity and/or production statistics for all pulp and paper mills under their control, with the result that capacity may be underestimated both in the aggregate and for individual firms and regions; (2) corporate parentage has been determined as accurately as possible from information presented in Lockwood-Post's, but may not completely reflect the centralization of ownership and control in the industry. Merger and acquisition activity since 1988, such as the recent merger of Georgia Pacific and Great Northern Nekoosa, is also not reflected in these statistics.

Approximately 265 firms produce pulp and/or paper in the United States. Of these, 115 are vertically integrated, producing both pulp and paper; 140 produce paper only, and 10 produce pulp only. These firms operate a total of approximately 310 pulp mills and 640 paper mills. Nearly all pulp mills (approximately 275) are integrated with an on-site paper mill; over half of all paper mills, however, are stand-alone operations not associated with a pulp mill located on the same site.

Pulp Production

The 310 U.S. pulp mills include some 370 separate pulp production lines, with a total capacity of approximately 177,000 short tons per day (tpd), or 65,000,000 tons per year. These mills produce pulp by a variety of methods: about 80% of pulp is produced by chemical methods, 9% is produced by mechanical methods, 7% by semi-chemical methods, and 4% by other methods (U.S. Bureau of Census, 1989). In 1988, U.S. EPA reported that 104 of these mills produce chlorine bleached chemical pulps (U.S. EPA, 1990).

Geographically, the industry is heavily concentrated. By census region, the South Atlantic states include some 20% of all pulp production lines in the U.S., and over 32% of all pulp capacity. The South Central states include an additional 24% of all production lines and 32% of capacity. The Southeastern U.S., therefore, includes nearly 45% of all U.S. pulp production lines, and nearly 65% of U.S. pulp capacity. An additional 15% of production lines and 15% of pulp capacity are located in the Pacific States, primarily in Oregon and Washington.

New England and the Middle Atlantic States include over 17% of all U.S. pulp production lines, but less than 9% of pulp capacity.

The pulp industry is dominated by relatively large firms. Of the approximately 125 firms active in the industry, the top five firms² control over 32% of U.S. pulp capacity. The top ten firms control 52% of all capacity, and the top twenty firms control over 70% of all capacity. Some 60% of all firms in the industry operate only a single pulp mill, and nearly 90% operate 5 or fewer mills.

Although, as previously stated, the vast majority of all pulp mills are integrated with an on-site paper mill, a large number of these pulp mills sell some of their output as market pulp in addition to what they use themselves in paper manufacturing. Of all U.S. pulp production, approximately 60% is consumed by paper mills integrated with a pulping operation; the remaining 40% is sold as market pulp to stand-alone paper plants.³

Paper Production

Total U.S. papermaking capacity is approximately 220,000 tpd (80,000,000 tons per year) at some 640 establishments. In terms of capacity, the papermaking industry exhibits a regional concentration similar to that of the pulp industry. Twenty-five percent of U.S. papermaking capacity is located in the South Atlantic States, and an additional 26% of U.S. capacity is located in the remaining Southeastern and South Central States. The Pacific States account for an additional 14% of U.S. papermaking capacity. Expressed in terms of number of establishments, however, the regional concentration is very different. New England and the Middle Atlantic States contain over 220 mills, or nearly 35% of all U.S. establishments, and the East North Central States include an additional 140 mills, or 22% of all U.S. mills. The South Atlantic and South Central States include only some 28% of all papermaking establishments, while 11% are located in the Pacific States.

The papermaking industry includes approximately 255 firms, over twice as many as the pulp industry. Of these, 140 firms operate paper mills only, and 115 firms operate both paper and pulp mills. Nearly 70% of all papermaking firms operate only a single establishment, and over 90% operate five or fewer establishments. Of the firms that operate only paper mills, over 80% operate only a single mill, and 98% operate five or fewer mills. Among firms that operate both pulp and papermaking establishments, 50% operate only one paper mill, 33% operate two to five mills, and 17% operate six or more mills.

²The top five firms based on pulping capacity are: International Paper, Stone Container, Georgia-Pacific, Weyerhaeuser, and Great Northern Nekoosa

³Appendix 2.A provides data on bleached and unbleached pulp production volumes for 99 of the 104 mills in the EPA study group.

Like pulpmaking capacity, U.S. paper capacity is heavily concentrated among the largest firms in the industry. The top five firms⁴ control approximately 27% of capacity, the top 10 firms control 46% of capacity, and the top twenty firms control 65% of capacity. Capacity is also significantly concentrated among the integrated pulp and papermaking firms; the 115 integrated firms control 90% of U.S. paper capacity, while the 140 firms that produce only paper control only 10% of capacity.

Paper Conversion

There are approximately 3,200 paper converting establishments in the United States. Nearly 30% of all converting establishments are located in New England and the Middle Atlantic States, and an additional 25% are located in the East North Central States. Fifteen percent are located in the South Atlantic States, approximately 12% in the South Central States, and approximately 11% in the Pacific States.

Distinction Between Paper and Paperboard Grades

Before proceeding to a description of the major paper and paperboard categories, the distinction between paper and paperboard should be made. The distinction between the two, while not sharp, lies in the heavier weight of the board grades. Paperboard is heavier, stiffer, and thicker than most paper. In general, any sheets greater than 0.012 inches in thickness are classified as paperboard.

2.2 Major Paper Product Categories

The paper products segment of the pulp and paper industry consists of four major product categories. These are: (1) newsprint, (2) printing, writing and related papers, (3) tissue, and (4) packaging and industrial papers. Within each of these there are various sub-categories or grades of products. An overview of each of the major categories and sub-categories is provided below, followed by historical and current data on the volume and value of product shipments.⁵ Explanations of the pulping processes mentioned below (e.g., mechanical, chemical, sulfate, sulfite) can be found in Chapter 3.

⁴The top five firms based on papermaking capacity are: International Paper, Stone Container, Georgia-Pacific, Champion International, and Weyerhaeuser.

⁵Appendix 2.B provides a comprehensive listing of 99 mill outputs for all paper and paperboard grades.

2.2.1 Description of Major Paper Product Groups

Newsprint. Newsprint is a light, inexpensive grade of paper made largely from mechanical pulps. Some unbleached sulfite or other chemical pulps may also be incorporated. A typical pulp mix for newsprint is 75 percent mechanical pulp and 25 percent bleached kraft pulp. The primary use of newsprint in the U.S. (75%) is for daily newspapers; weeklies, comic books, and low-cost advertising and printing account for the remainder. Imports, primarily from Canada, account for over 60 percent of U.S. consumption.

Printing, Writing & Related Papers. This large category includes a wide variety of coated and uncoated papers utilized by business, consumer, and commercial users. The main sub-categories are listed below.

Uncoated groundwood paper. A grade higher than newsprint, uncoated groundwood is widely used in newspaper inserts, catalogs, paperback books, and directories. Compared with newsprint, it is both smoother and brighter. Under industry consensus definitions, groundwood grades contain more than 10 percent groundwood or other mechanical pulps in their furnish, but common furnishes include up to 50 or 100 percent groundwood. Magazine stock is commonly produced with 60-70 percent mechanical and 30-40 percent chemical pulp. Imports account for approximately 50 percent of U.S. consumption of uncoated groundwood paper.

Coated groundwood paper. Papers with a wide variety of coatings are produced for different end uses. The most common, however, uses a clay coating based on aluminum silicate (kaolin). Coated groundwood papers accounted for 56 percent of all coated papers in 1989. Lower grades of coated groundwood compete with uncoated groundwood, while higher grades may compete with coated free sheet. End uses for these papers include advertising, magazines, Sunday newspaper supplements, and catalogs.

Uncoated free sheet. By definition, free sheet contains no more than 10 percent mechanical pulps. Until recently, most papers sold as free sheet met that standard. Considerable advancement has been made recently, however, that allows a higher percentage of mechanical pulp to be used without degrading the quality of the paper. Thus, industry observers believe that papers containing 20 or even 30 percent mechanical pulps are being commonly sold as free sheet. Uncoated free sheet represents the largest single category of paper, accounting for about 30 percent of all paper products shipments. The category encompasses most grades of business paper, including forms, bond, stationary, tablet, envelope, xerox and computer paper, as well as cover and text grades used in printing. Several of these grades are now being made with a recycled stock component, using both pre- and post-consumer waste. U.S. producers account for over 95 percent of U.S. uncoated free sheet consumption.

Coated free sheet. Coated free sheet encompasses several types of surface finishes, including gloss, dull, matte, and embossed. Gloss accounts for approximately 85 percent of production, and is used for catalogs, advertising materials, and high quality magazines and books.

Bleached bristols. Bristols are high quality cardboards used for products such as index tags, cards, file folders, and postcards.

Cotton fiber writing paper and thin paper. Papers in which cotton or other non-wood fibers comprise 25 percent or more of the total. Also referred to as rag content paper.

Tissue. Tissue is a class of light, fairly transparent paper characterized by its gauze-like texture. It is widely used in sanitary products such as bathroom tissue, facial tissue, napkins, and toweling. The industry also produces several non-sanitary tissue grades, such as waxing, wrapping, and wadding tissue. About 60 percent of tissue is purchased by end-use consumers in grocery stores, with the remainder bought for commercial, industrial, and institutional uses. Bleached kraft and sulfite pulps are most common, although all pulp types are used to some extent. Tissue accounts for approximately 13.5 percent of total paper shipments. The percentage of recycled fibers used in tissue production has increased in recent years, to the extent that recycled stock comprises an average of 30 to 40 percent of production of some grades. Particular brands of tissue may be produced with 100 percent recycled fibers.

Packaging & Industrial Converting Paper. This category includes various types of paper used for industrial or commercial purposes. The largest product classes are wrapping papers and bag and sack stock. Also included are specialty papers such as butcher paper and grease-proof and glassine paper. The products in this category may be from either bleached or unbleached kraft pulp. Overall, this category accounts for approximately 12-13 percent of total U.S. paper shipments.

2.2.2 Current and Historical Production Volumes

Shipments of paper products in the U.S. totalled 38.3 million tons in 1988. Printing and writing papers accounted for 56 percent of this total, followed by newsprint (16%), tissue (14%), and packaging and industrial papers (13%). The single largest paper product category, uncoated free sheet, had shipments totaling 11.2 million tons in 1988. This represented 51 percent of the printing and writing total, and 29 percent of all paper products.

Table 2.1 and Figure 2.1 present data on shipments of the major paper grades at 5-year intervals over the period 1963-88. Figure 2.2 shows a breakdown for subcategories of the largest main group, printing and writing papers. Because consistent data for paperboard products is available only for the period 1973-88, the comparisons for both groups will focus on this most recent 15-year period. As seen in the last column of the table, between 1973 and 1988 shipments of paper products grew from 26.8 million to 38.3 million tons, for an increase of 43 percent. In comparison, the U.S. gross national product (GNP), measured in constant dollars, increased by 47 percent during the same time period. Hence, paper product growth from 1973 to the present has kept pace with overall growth of the U.S. economy.

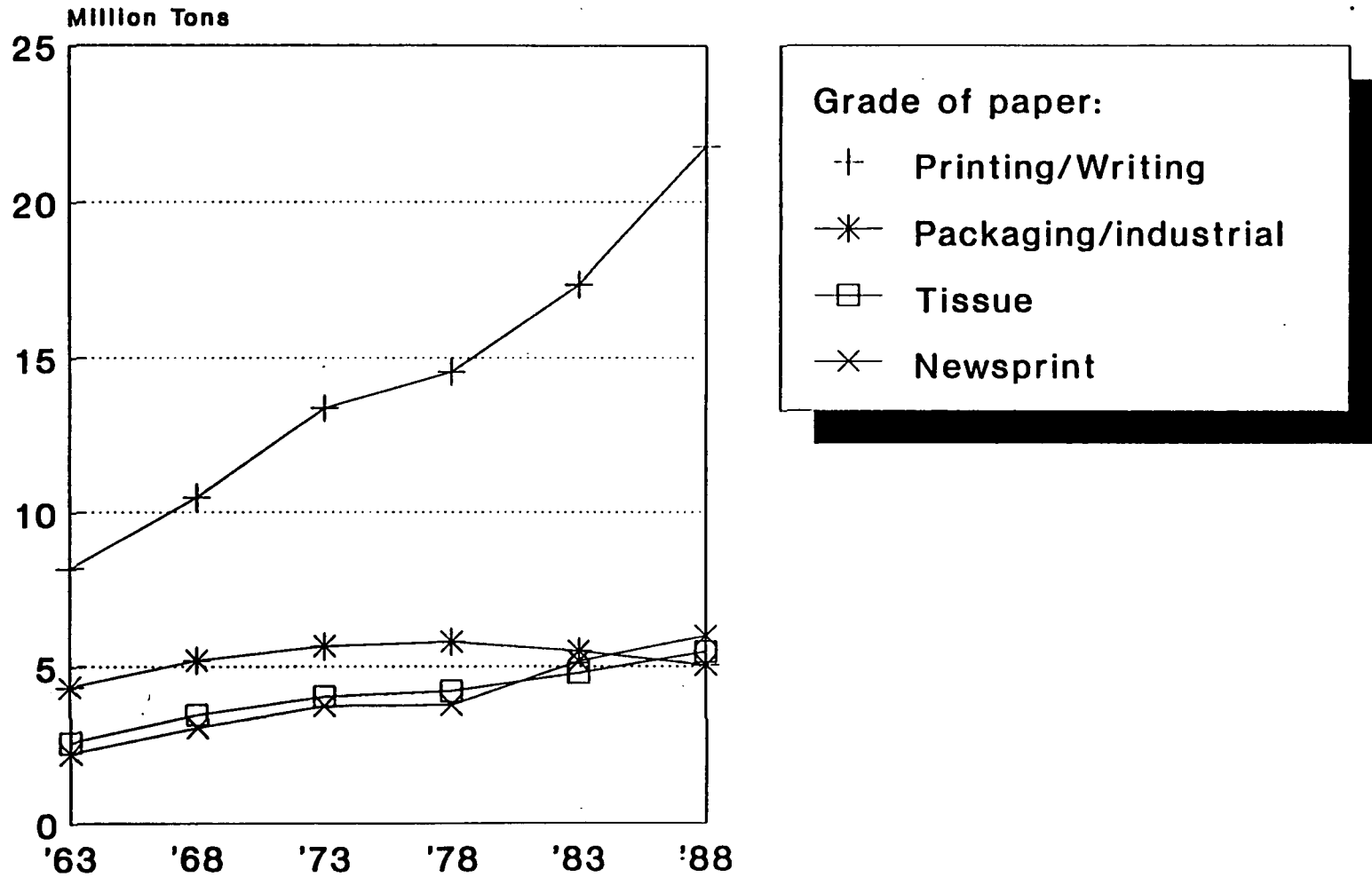
Table 2.1
U.S. Paper Products Shipments 1963-88
Selected Years
('000 Tons)

	1963	% change 1963-68	1968	% change 1968-73	1973	% change 1973-78	1978	% change 1978-83	1983	% change 1983-88	1988	% change 1963-88	% change 1973-88
All Paper Grades	17,320	28.1%	22,181	20.8%	26,797	5.7%	28,320	15.9%	32,816	16.7%	38,298	121.1%	42.9%
Newsprint	2,218	37.3%	3,045	22.8%	3,738	0.8%	3,768	37.1%	5,167	15.8%	5,982	169.7%	60.0%
Printing/writing papers	8,185	28.1%	10,482	27.6%	13,371	8.8%	14,549	19.4%	17,365	25.5%	21,793	166.3%	63.0%
Uncoated groundwood	956	14.0%	1,090	8.3%	1,181	14.7%	1,354	13.0%	1,531	6.1%	1,624	69.8%	37.5%
Coated papers	2,425	27.8%	3,101	21.9%	3,779	16.4%	4,400	29.9%	5,716	28.7%	7,359	203.4%	94.7%
Uncoated free sheet	3,634	31.7%	4,788	39.4%	6,674	7.9%	7,202	21.2%	8,726	29.2%	11,277	210.3%	69.0%
Thin papers	179	46.4%	262	36.9%	358	-1.8%	352	-16.9%	292	-26.0%	217	21.2%	-39.6%
Cotton fiber papers	119	4.4%	124	-0.2%	124	-7.5%	114	16.0%	133	25.8%	167	40.6%	35.0%
Bleached bristols	870	28.4%	1,117	12.4%	1,256	-10.3%	1,126	-14.1%	967	18.8%	1,150	32.1%	-8.5%
Packaging/industrial papers	4,342	19.7%	5,199	8.7%	5,649	2.5%	5,789	-5.1%	5,495	-8.2%	5,047	16.2%	-10.7%
Unbleached kraft papers	3,051	18.1%	3,603	8.3%	3,902	-1.0%	3,863	-9.3%	3,505	-20.1%	2,800	-8.2%	-28.2%
Bleached packaging papers	782	20.6%	943	-8.0%	867	28.6%	1,115	-61.5%	429	8.3%	465	-40.5%	-46.4%
Glassine, greaseproof, & vegetable parchment	183	7.5%	208	11.0%	231	12.4%	259	96.1%	508	17.4%	596	208.6%	158.7%
Special industrial papers	314	41.8%	446	45.8%	650	-15.2%	551	91.1%	1,053	12.6%	1,186	277.2%	82.4%
Tissue Paper	2,576	34.1%	3,456	16.9%	4,039	4.4%	4,215	13.6%	4,789	14.4%	5,476	112.5%	35.6%
Toilet tissue	1,055	20.7%	1,273	13.1%	1,441	14.1%	1,643	11.7%	1,835	10.7%	2,032	92.7%	41.1%
Facial tissue stock	278	25.6%	350	3.4%	362	-9.1%	329	18.3%	389	-9.7%	351	26.2%	-2.9%
Napkin stock	261	43.4%	375	19.5%	448	10.1%	493	8.0%	533	30.9%	697	166.9%	55.8%
Towelling	663	62.6%	1,078	18.4%	1,276	3.2%	1,318	19.7%	1,577	18.1%	1,863	181.1%	46.0%
Wiper stock	33	52.0%	50	21.9%	61	-26.9%	45	-	NA	-	NA	-	-
Other sanitary tissue	50	83.0%	92	101.2%	184	3.0%	190	46.0%	277	22.1%	338	576.0%	83.6%
All other tissues	236	1.1%	239	11.9%	267	-26.1%	197	-10.1%	177	9.2%	194	-17.9%	-27.5%
REAL U.S. GNP (1982 \$billions)	1,873	26.3%	2,366	16.0%	2,744	13.5%	3,115	19.7%	3,729	7.9%	4,024	114.8%	46.7%

Source: 1989 API Statistics of Paper, Paperboard, & Wood Pulp.

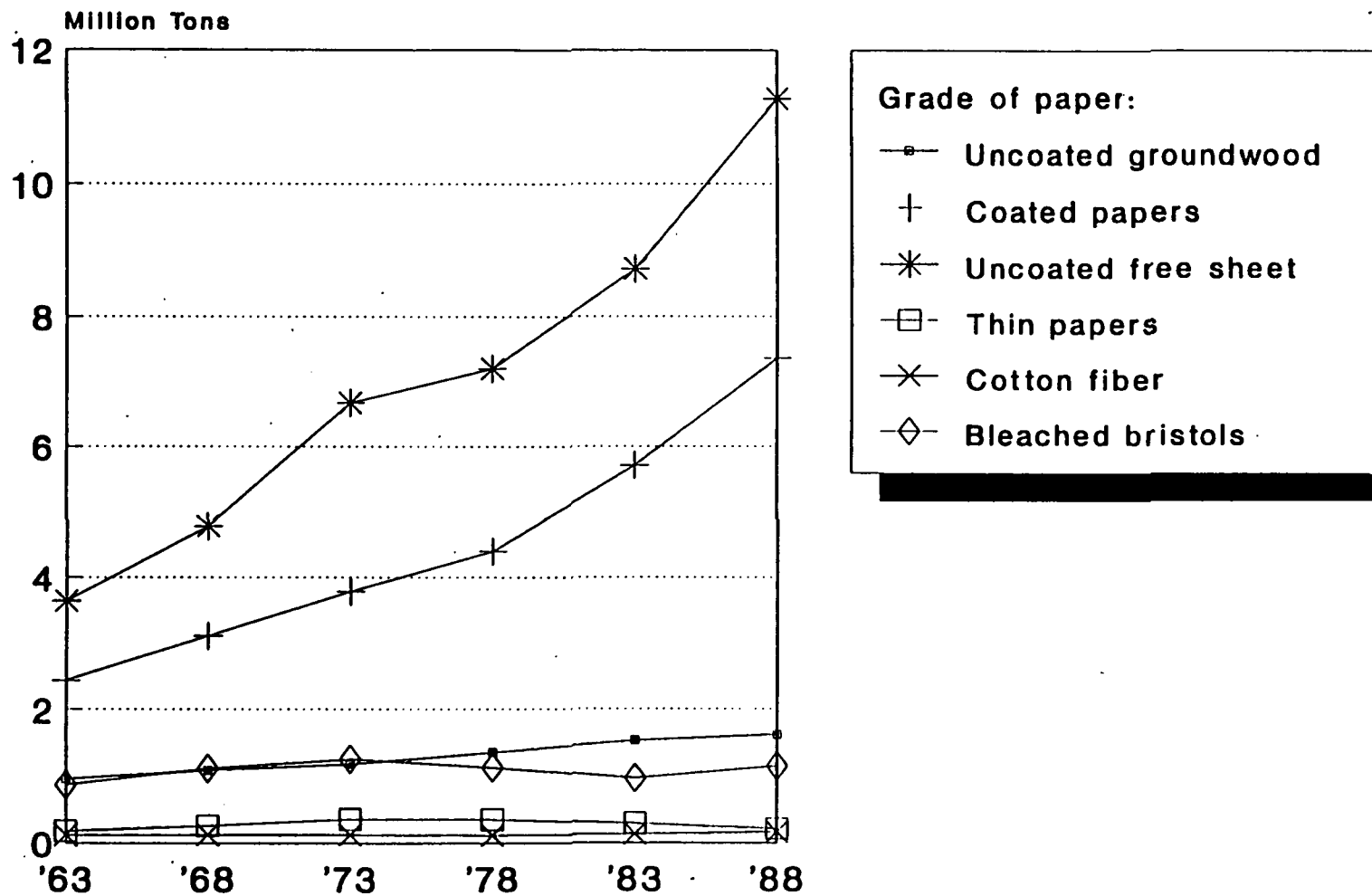
Note: Totals may not add due to rounding.

Figure 2.1
Shipments of Main Paper Products Groups
1963-1988



Source: API 1989 Statistics of Paper, Board, & Wood Pulp.

Figure 2.2
Shipments of Printing/Writing Papers
1963-1988



Source: API 1989 Statistics of Paper, Board, & Wood Pulp.

Within the major product categories, however, there has been considerable variation in growth rates, with newsprint and printing/writing papers experiencing considerably higher growth. In the period 1973-1988 growth rates for the main product groups were as follows:

- Newsprint (60%)
- Printing, writing & related papers (63%)
- Packaging & industrial papers (-11%)
- Tissue (36%)

Shipments of uncoated free sheet grew from 6.7 million to 11.3 million tons over this period, an increase of 69 percent.

2.2.3 Current Value of Production

To provide an estimate of the current value of paper shipments, this analysis relied on the 1989 Current Industrial Report on Pulp, Paper and Board from the U.S. Bureau of the Census. This report provides Census estimates of both the volume and value of shipments in the current and previous year. The American Paper Institute's reports present estimates of the volume but not the value of shipments. While the shipment volume estimates differ slightly between the two sources, due to differences in the coverage and estimation methods, value per ton figures calculated from the Census sources can be applied to the appropriate API categories to obtain an estimated value of shipments. In Table 2.2, the Census value per ton figures are applied to the 1988 API shipment volumes to obtain an estimate of current year volume and value of production.

As seen in the table, the 38.3 million tons of paper products shipped in 1988 had an estimated value of \$32.2 billion. Average value per ton for all paper was \$843. Higher valued grades include: cotton fiber papers (\$2,401 per ton), thin papers (\$1,811 per ton), other sanitary tissue (\$1,504 per ton), and special industrial papers (\$1,532 per ton). Uncoated free sheet, the largest single volume category, had an average value per ton of \$863. At \$528 per ton, newsprint represents the lowest value grade.

2.2.4 Current value of imports and exports

U.S. imports and exports of paper products are shown in Table 2.3. In general, export volumes of paper products are minor, amounting to only 3 percent of shipments in 1988. Two product categories merit additional note. In 1988 the U.S. exported some 427,000 tons of newsprint (or 7% of shipments) and 185,000 tons of special industrial papers (16% of shipments). According to Census Bureau figures, exports of all paper and paperboard products increased from \$2.2 billion in 1987 to an estimated \$3.3 billion in 1990, an increase of 48 percent.

In total, the U.S. imported 12.0 million tons of paper products, which represents 24.4 percent of domestic consumption. The U.S. reliance on Canadian newsprint is the most prominent feature. Imports of newsprint exceeded 8.8 million tons in 1988, compared to total

TABLE 2.2
Volume of U.S. Paper Shipments,
Value per Ton, and Estimated Shipments Value
(1988)

Product Category	Volume of Shipments (Thousand Tons)	Value Per Ton [a] \$	Estimated Value of Shipments (\$Millions)
All Paper	38,298	842.8	32,278
Newsprint	5,982	527.8	3,157
Printing/writing papers	21,793	889.0	19,373
Uncoated groundwood	1,624	680.3	1,105
Coated papers	7,359	931.0	6,851
Uncoated free sheet	11,277	862.9	9,731
Thin papers	217	1,810.6	392
Cotton fiber papers	167	2,400.5	401
Bleached bristols	1,150	777.6	894
Packaging/industrial papers	5,047	847.9	4,279
Unbleached kraft papers	2,800	499.3	1,398
Bleached packaging papers	465	590.2	274
Glassine, greaseproof, & vegetable parchment	596	1,326.5	791
Special industrial papers	1,186	1,531.5	1,816
Tissue Paper	5,476	998.4	5,467
Toilet tissue	2,032	940.8	1,912
Facial tissue stock	351	1,298.5	456
Napkin stock	697	1,014.0	707
Towelling	1,863	893.2	1,664
Other sanitary tissue	338	1,504.3	508
All other tissues	194	1,131.6	219

Source: 1989 API Statistics of Paper, Paperboard, & Wood Pulp.

[a] Value per ton figures at the most detailed product category level are from corresponding product categories in Bureau of the Census (1989). For higher level categories, the value per ton is calculated as the sum of shipment values for all sub-categories divided by the sum of shipments.

Table 2.3
U.S. Imports, Exports, and Apparent Domestic Consumption
of Paper Products, by Grade, 1988
('000 Tons)

	Exports			Imports		Apparent Domestic Consumption [a]
	Shipments	'000 Tons	% Shipments	'000 Tons	% Shipments	
All Paper Grades	38,298	1,102	2.9%	12,017	31.4%	49,212
Newsprint	5,982	427	7.1%	8,802	147.1%	14,356
Printing/writing papers	21,793	287	1.3%	2,812	12.9%	24,318
Uncoated groundwood	1,624	70	4.3%	1,363	83.9%	2,916
Coated papers	7,359	97	1.3%	798	10.8%	8,059
Uncoated free sheet	11,277	83	0.7%	592	5.2%	11,786
Cotton fiber/Thin Papers	384	34	8.9%	56	14.5%	406
Bleached bristols	1,150	3	0.2%	4	0.4%	1,151
Packaging/industrial papers	5,047	347	6.9%	343	6.8%	5,044
Unbleached kraft papers	2,800	135	4.8%	162	5.8%	2,827
Bleached packaging papers	465	20	4.2%	146	31.4%	591
Glassine, greaseproof, & vegetable parchment	596	32	5.4%	24	4.1%	588
Special industrial papers	1,186	185	15.6%	11	0.9%	1,012
Tissue Paper	5,476	41	0.8%	60	1.1%	5,494

Source: 1989 API Statistics of Paper, Paperboard, & Wood Pulp.

[a] Apparent Domestic Consumption is equal to shipments plus imports less exports.

domestic production of 6.0 million tons. Close to 1.4 million tons of uncoated groundwood were also imported; this compares to domestic production of 1.6 million tons. Imports of bleached packaging papers, at 146,000 tons, represented over 30 percent of domestic shipments. Between 1987 and 1990, the value of all paper and paperboard product imports rose from \$5.9 to \$7.9 billion dollars. This represented an increase of 32.6 percent (U.S. Department of Commerce, 1990).

Apparent domestic consumption of paper products can be calculated by adding net imports to domestic shipments. In 1988, apparent domestic consumption of paper products was 49.2 million tons. Of this, printing and writing papers accounted for 49 percent and newsprint for 29 percent.

2.3 Major Paperboard Product Grades

Paperboard is the second major subdivision of the paper industry. Unlike the various paper grades, the paperboard product categories are broken down first according to the primary pulp type used and second according to type of product. Hence, there is a list of products under each of the following: (1) unbleached kraft paperboard; (2) solid bleached kraft paperboard; (3) semichemical paperboard; and (4) recycled paperboard. Most of the overlap is in products which are produced from both bleached and unbleached pulps, e.g. linerboard. Other products are made predominantly with a single pulp type, e.g. milk carton board. An overview of these product divisions is provided below, followed by current and historical data on the volume and value of paperboard product shipments.

2.3.1 Description of Major Paperboard Product Groups

Unbleached paperboard. Unbleached paperboard can be divided into the three categories described below.

Unbleached kraft linerboard. Unbleached kraft linerboard, a subset of containerboard, is used for facing materials in the production of corrugated containers, and accounts for 41 percent of all paperboard output.

Tube, can, and drum board. Includes any unbleached board stock used for lining fibre or composite cans, tubes, cores, and drums. Tubes and cores are of similar construction, but have different end uses. Tubes are used as rolls for shipping items such as calendars and posters, while cores are used as rolls onto which products such as carpets and paper are wound to provide support and ease of handling. The main use of fibre drums is to ship dry bulk products.

Other unbleached packaging and industrial converting kraft paperboard. This residual category includes corrugating medium and folding carton type board made from unbleached kraft pulps.

Solid bleached kraft paperboard. This paperboard category is also known as solid bleached sulfate, or SBS. SBS is used mainly for folding carton and milk carton packaging. Industry consensus is that this grade is produced using a minimum of 80 percent virgin bleached wood stock, though in practice a somewhat lower percentage may be used. Most bleached kraft board is coated with either clay or polyethylene.

Bleached kraft linerboard. Compared to unbleached board, only a small percentage of linerboard production is from bleached kraft pulp (127,000 out of 11.3 million tons). The main end use is in facings for corrugated boxes and containers.

Folding carton type board. A subset of boxboard, used in the manufacture of "folding type" containers. These are boxes which are formed, filled, and closed by the user (as distinguished from "setup type" boxes, which are rigid). Folding type board accounts for about half of all bleached paperboard.

Milk carton board. A special grade of bleached boxboard capable of being converted into containers for milk, cream, and other beverages (e.g. aseptic juice containers). Milk cartons account for 40 percent of SBS production.

Cup and nested container board. A bleached paperboard used in the manufacture of cups and other nested cylindrical containers. Used for hot and cold drinks and in the packaging of moist, liquid, and oily foods.

Semichemical paperboard. Semichemical pulps are those produced by a mild chemical treatment of the raw materials followed by a mechanical defiberizing operation. The most common semichemical process is known as the neutral sulfite process, which produces neutral sulfite semichemical (NSSC) pulp. Nearly all of semichemical paperboard production is used for corrugating medium, which forms the inner, fluted layer of cardboard and corrugated containers. Approximately 75 percent of all corrugating medium is from semichemical pulp (which normally contains 20 percent recycled fiber), while the remainder is from scrap paper stock.

Recycled paperboard. Recycled board is made from a combination of recycled fibers from various grades of paper stock. Major uses include: folding boxboard, core/can/tube grades, corrugating medium, and gypsum linerboard.

2.3.2 Current and Historical Production Volumes

Shipments of paperboard products totalled 38.1 million tons in 1988, representing 50 percent of all paper and paperboard shipments. Table 2.4 and Figure 2.3 present data on shipments by product grade. By combining data from Tables 2.1 and 2.4, it shows that the paperboard share of the overall paper and board market has fallen very slightly over time, from 52.4 percent in 1973, to 51.6 percent in 1978, to 49.5 percent in 1983 and 49.9 percent in 1988. Between 1973 and 1988, however, paperboard shipments have increased by only 29 percent in

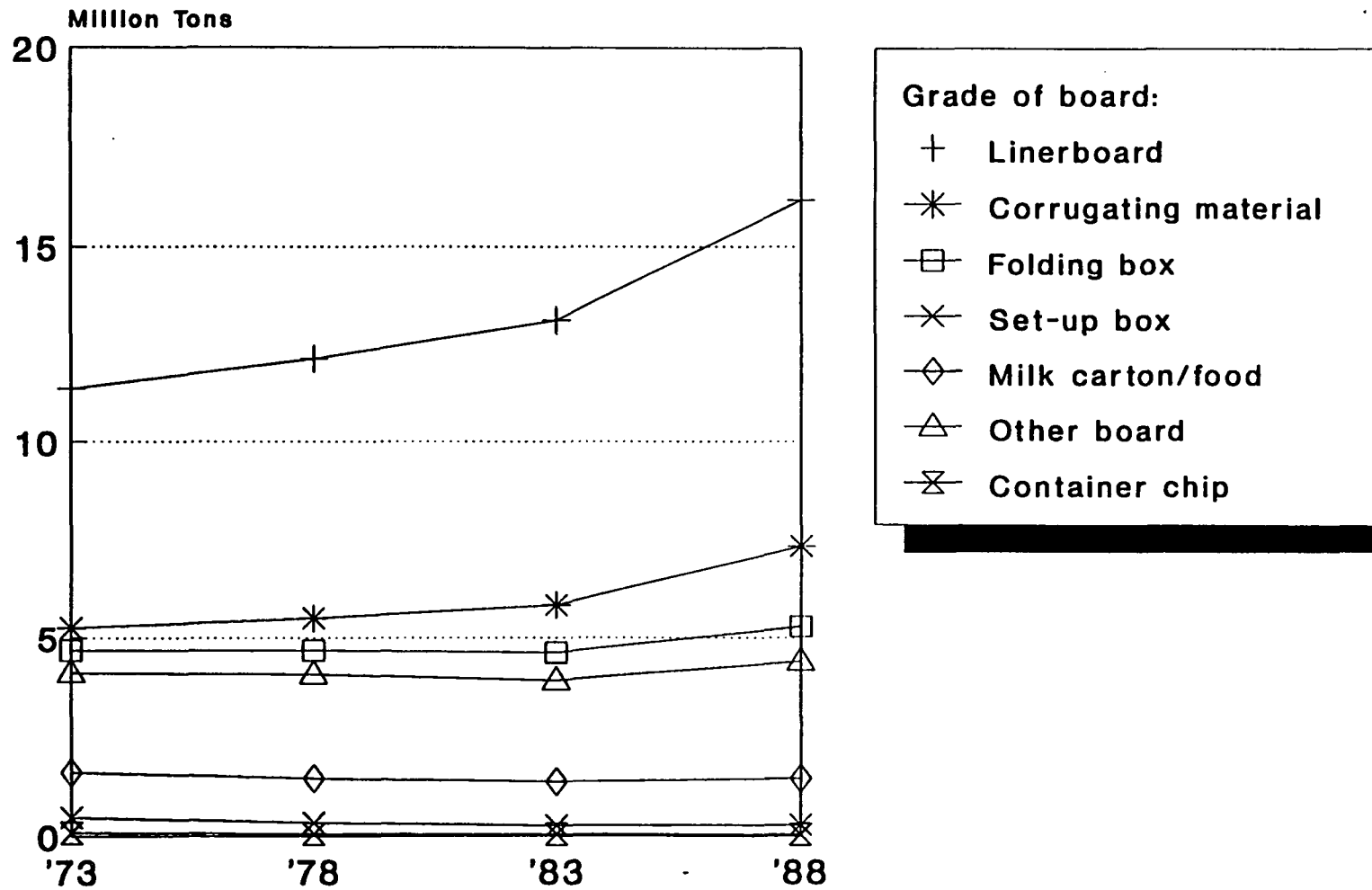
TABLE 2.4
U.S. Paperboard Products Shipments by Grade
Selected Years 1973-1988
('000 Tons)

Grade	1973	% change 1973-78	1978	% change 1978-83	1983	% change 1983-88	1988	% change 1973-88
All Paperboard	29,549	2.4%	30,251	6.3%	32,148	18.5%	38,104	29.0%
Containerboard	16,690	6.0%	17,687	7.4%	19,000	24.0%	23,563	41.2%
Linerboard	11,356	6.9%	12,134	8.2%	13,125	23.3%	16,177	42.5%
Unbleached kraft	10,939	7.5%	11,782	8.2%	12,722	22.6%	15,601	42.6%
Solid bleached	128	-9.4%	116	-0.6%	115	47.7%	170	33.0%
Recycled	289	-11.3%	256	12.8%	289	40.6%	407	40.7%
Corrugating material	5,255	4.7%	5,503	6.1%	5,838	25.9%	7,351	39.9%
Unbleached kraft	2	-	-	-	-	-	-	-
Semichemical	4,124	4.4%	4,305	5.3%	4,533	22.0%	5,528	34.0%
Recycled	1,129	6.1%	1,198	9.0%	1,305	39.7%	1,823	61.6%
Container chip & filler	69	-27.5%	50	-26.3%	37	-5.4%	35	-49.4%
Unbleached kraft	10	77.5%	18	-	-	-	-	-
Recycled	69	-53.2%	32	15.3%	37	-5.4%	35	-49.0%
Boxboard	6,742	-4.2%	6,457	-3.5%	6,230	12.6%	7,014	4.0%
Folding	4,682	0.1%	4,688	-1.5%	4,615	14.7%	5,292	13.0%
Unbleached kraft	455	35.8%	618	15.0%	710	30.1%	924	103.1%
Solid bleached	1,706	2.0%	1,740	-2.6%	1,694	19.0%	2,018	18.2%
Recycled	2,522	-7.9%	2,321	-4.7%	2,211	6.4%	2,352	-6.7%
Set-up	465	-28.5%	333	-23.0%	256	8.7%	279	-40.1%
Recycled	465	-28.5%	333	-23.0%	256	8.7%	279	-40.1%
Milk carton & food service	1,594	-9.3%	1,446	-6.1%	1,359	6.2%	1,443	-9.5%
Solid bleached	1,594	-9.3%	1,446	-6.1%	1,359	6.2%	1,443	-9.5%
Recycled	-	-	-	-	-	-	-	-
Other	4,102	-0.9%	4,067	-4.0%	3,904	12.6%	4,396	7.2%
Gypsum wallboard facing	1,050	4.2%	1,094	-3.7%	1,054	12.1%	1,182	12.5%
Recycled	1,050	4.2%	1,094	-3.7%	1,054	12.1%	1,182	12.5%
Tube, can, & drum	1,145	1.5%	1,163	4.1%	1,211	16.6%	1,411	23.2%
Unbleached kraft	226	10.8%	251	-18.5%	204	-23.9%	155	-31.3%
Semichemical	18	-20.2%	15	-	-	-	-	-
Recycled	901	-0.3%	898	12.1%	1,007	21.8%	1,226	36.1%
All Other	1,907	-5.1%	1,810	-9.4%	1,639	10.0%	1,804	-5.4%
Unbleached kraft	333	-22.5%	258	-20.0%	207	-20.2%	165	-50.5%
Solid bleached	134	65.2%	221	-3.4%	213	19.7%	255	90.9%
Semichemical	10	-98.1%	0	2450.0%	5	-	-	-
Recycled	1,430	-6.9%	1,331	-8.7%	1,215	13.9%	1,384	-3.2%
Exports	2015	1.2%	2040	47.6%	3012	4.0%	3131	55.4%
Unbleached Kraft	1597	-8.2%	1466	55.6%	2281	0.7%	2296	43.8%
Solid bleached	280	54.6%	433	18.7%	514	22.0%	627	123.9%
Semichemical	107	11.2%	119	62.2%	193	-29.5%	136	27.1%
Recycled	31	-29.0%	22	9.1%	24	200.0%	72	132.3%
REAL U.S. GNP (1982 \$billions)	2,744	13.5%	3,115	19.7%	3,729	7.9%	4,024	46.7%

Source: 1989 API Statistics of Paper, Paperboard, & Wood Pulp.

Note: Totals may not add due to rounding.

Figure 2.3
Shipments of Main Paperboard
Products Groups 1973-1988



Source: API 1989 Statistics of Paper, Board, & Wood Pulp.

comparison to 42.9 percent for paper products and 46.7 percent for the economy as a whole (as measured by real GNP).

Within paperboard, the major grades and their share of production are: containerboard (62%), boxboard (18%), and other types of board (20%). The lower growth rate of paperboard compared to paper is due primarily to slow growth in the boxboard and "other" board segments.

The containerboard category, which encompasses linerboard and corrugating material, grew by 41 percent, from 16.7 million to 23.6 million tons. Boxboard shipments, on the other hand, grew by only 4 percent overall, from 6.7 million to 7.0 million tons. This resulted from a decline in setup board shipments of 40 percent and a near 10 percent decrease in milk carton and food service board (e.g., cups, dishes).

In Table 2.5, the same data has been recategorized and is presented according to type of fiber utilized in each product category. Figure 2.4 also provides a fiber-based perspective of the data. Overall in 1988, unbleached kraft accounted for 50 percent of all paperboard shipments, of which 82 percent is linerboard. Solid bleached board comprised 12 percent of the total. About 45 percent of this was folding boxboard, and another 32 percent was milk carton and food service products. Semichemical pulps, which accounted for 15 percent of all paperboard, was almost entirely used for corrugating materials. Recycled fibers, meanwhile, comprised 23 percent of all paperboard. A variety of end products in multiple categories are made from recycled fiber.

2.3.3 Current Value of Production

In 1988, paperboard product shipments were valued at \$15.3 billion (see Table 2.6). Average value per ton for all paperboard products is estimated at \$401.8, which is considerably less than the average value (\$842.8) for paper products (see Table 2.2). The lower value per ton is illustrated by the fact that in 1988 paperboard accounted for approximately 50 percent of shipment volume but only 30 percent of value. Solid bleached board product grades are among the highest in value. For example, milk carton and food service board had an average value of \$638.7 per ton. Solid bleached folding boxboard had a similar value of \$616.7 per ton. Recycled and unbleached kraft board have values in the range of \$300-400 per ton.

2.3.4 Current Value of Imports and Exports

As shown in Table 2.7, in the paperboard categories, exports represent approximately 10 percent of domestic U.S. shipments volume, while imports are less than 1 percent of shipments. The largest export category is unbleached kraft board. In 1988, the U.S. shipped 2.5 million tons of unbleached kraft board overseas, an amount that represents 13 percent of domestic production. Greater than 20 percent of bleached kraft board production, or 924,000 tons in total, were also exported. Linerboard contributes more to U.S. exports than containerboard because of its relative ease of transportation. The primary markets for U.S. linerboard are the Pacific Rim, Europe, Latin America, and Australia. Mexico and Canada purchased the majority of the U.S. corrugated box exports, which were valued at \$197 million in 1989. Exports of folding cartons and set-up boxes amounted to only \$88 and \$23 million respectively in 1989. The majority of these shipments also went to nearby Canada and Mexico.

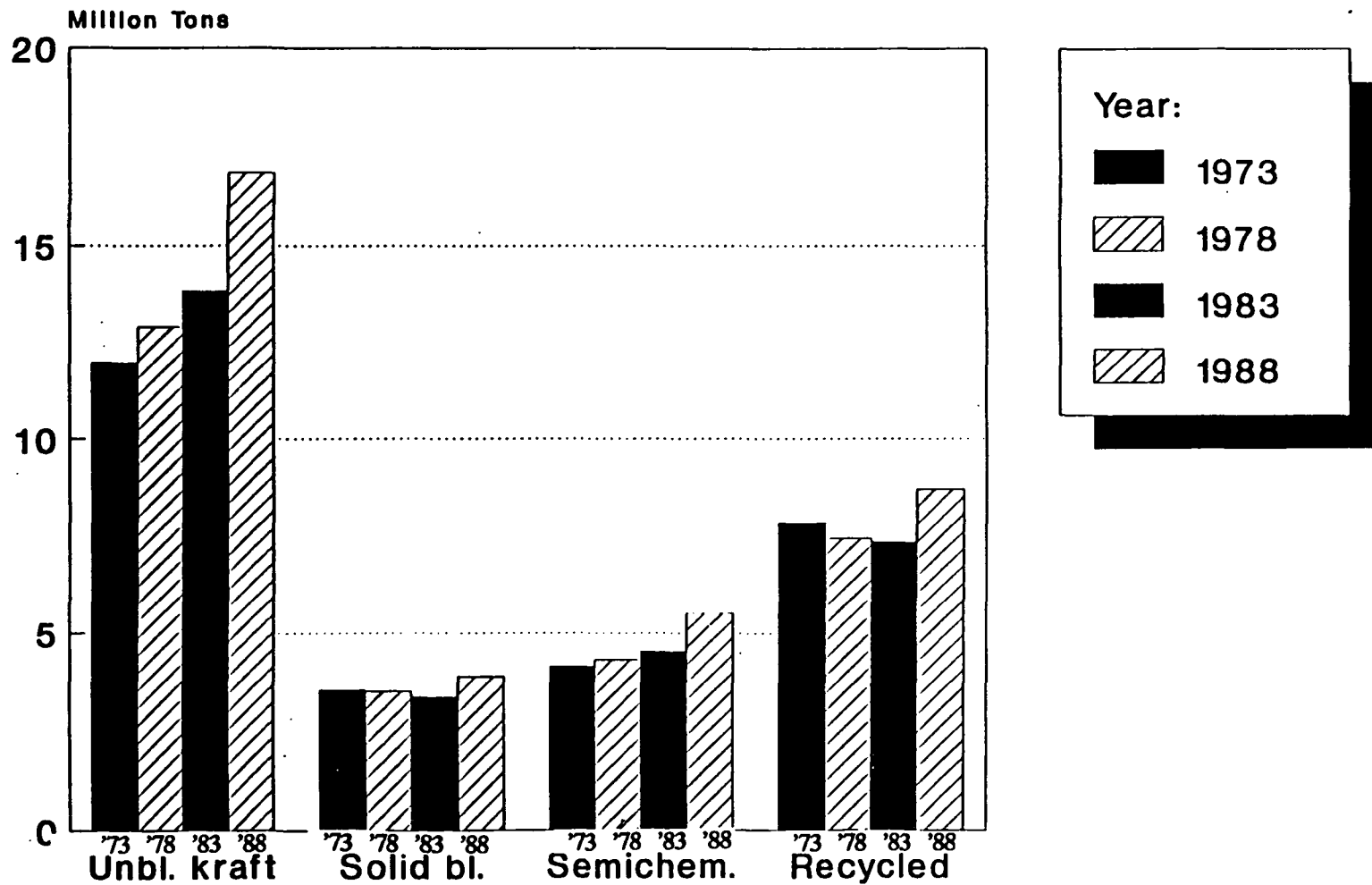
TABLE 2.5
U.S. Paperboard Products Shipments by Type of Fiber
Selected Years 1973-1988
(⁰⁰⁰ Tons)

Grade	1973	% change 1973-78	1978	% change 1978-83	1983	% change 1983-88	1988	% change 1973-88
All Paperboard	29,549	2.4%	30,251	6.3%	32,146	18.5%	38,105	29.0%
Unbleached kraft	13,563	7.9%	14,373	7.2%	16,122	21.7%	19,140	40.8%
Containerboard	10,952	7.6%	11,780	8.0%	12,721	22.6%	15,601	42.5%
Linerboard	10,939	7.5%	11,762	8.2%	12,722	22.6%	15,601	42.6%
Corrugating material	2	-	-	-	-	-	-	-
Container chip & filler	10	77.5%	18	-	-	-	-	-
Boxboard	455	35.8%	618	15.0%	710	30.1%	924	103.1%
Folding	455	35.8%	618	15.0%	710	30.1%	924	103.1%
Other	559	-9.0%	509	-19.3%	411	-22.1%	320	-42.8%
Tube, can, & drum	226	10.8%	251	-18.5%	204	-23.9%	155	-31.3%
All other	333	-22.5%	258	-20.0%	207	-20.2%	165	-50.5%
Export	1597	-8.2%	1466	55.6%	2281	0.7%	2296	43.8%
Solid bleached	3,842	-1.1%	3,955	-4.0%	3,895	14.9%	4,511	9.1%
Containerboard	128	-9.4%	116	-0.6%	115	47.7%	170	33.0%
Linerboard	128	-9.4%	116	-0.6%	115	47.7%	170	33.0%
Boxboard	3,300	-3.5%	3,186	-4.2%	3,052	13.3%	3,459	4.8%
Folding	1,706	2.0%	1,740	-2.6%	1,694	19.0%	2,016	18.2%
Milk carton & food service	1,594	-9.3%	1,446	-6.1%	1,359	6.2%	1,443	-9.5%
Other	134	65.2%	221	-3.4%	213	19.7%	255	90.9%
All Other	134	65.2%	221	-3.4%	213	19.7%	255	90.9%
Export	280	54.6%	433	18.7%	514	22.0%	627	123.9%
Semichemical	4,260	4.0%	4,439	5.0%	4,730	21.8%	5,664	33.1%
Containerboard	4,124	4.4%	4,305	5.3%	4,533	22.0%	5,528	34.0%
Corrugating material	4,124	4.4%	4,305	5.3%	4,533	22.0%	5,528	34.0%
Other	29	-48.3%	15	-66.2%	5	-	-	-
Tube, can, & drum	18	-20.2%	15	-	-	-	-	-
All Other	10	-98.1%	0	-	5	-	-	-
Export	107	11.2%	119	62.2%	193	-29.5%	136	27.1%
Recycled	7,885	-5.0%	7,485	-1.2%	7,398	18.2%	8,789	11.0%
Containerboard	1,486	0.0%	1,486	9.8%	1,632	38.8%	2,265	52.4%
Linerboard	289	-11.3%	256	12.8%	289	40.6%	407	40.7%
Corrugating material	1,129	6.1%	1,198	9.0%	1,305	39.7%	1,823	61.6%
Container chip & filler	69	-53.2%	32	15.3%	37	-5.4%	35	-49.0%
Boxboard	2,987	-11.1%	2,654	-7.0%	2,468	6.6%	2,631	-11.8%
Folding	2,522	-7.9%	2,321	-4.7%	2,211	6.4%	2,352	-6.7%
Set-up	465	-28.5%	333	-23.0%	256	8.7%	279	-40.1%
Milk carton & food service	-	-	-	-	-	-	-	-
Other	3,381	-1.7%	3,323	-1.4%	3,275	15.8%	3,791	12.1%
Gypsum wallboard facing	1,050	4.2%	1,094	-3.7%	1,054	12.1%	1,182	12.5%
Tube, can, & drum	901	-0.3%	898	12.1%	1,007	21.8%	1,226	36.1%
All Other	1,430	-6.9%	1,331	-8.7%	1,215	13.9%	1,384	-3.2%
Exports	31	-29.0%	22	8.1%	24	200.0%	72	132.3%
REAL U.S. GNP (1982 \$billions)	2,744	13.5%	3,115	19.7%	3,729	7.9%	4,024	46.7%

Source: 1989 API Statistics of Paper, Paperboard, & Wood Pulp.

Note: Totals may not add due to rounding.

Figure 2.4
Shipments of Main Paperboard
Product Groups 1973-1988



Source: API 1989 Statistics of Paper, Board, & Wood Pulp.

Table 2.6
Volume of U.S. Paperboard Shipments,
Value per Ton, and Estimated Shipments Value
(1988)

Product Category	Volume of Shipments (Thousand Tons)	Value Per Ton [a]	Estimated Value of Shipments (\$Millions)
All Paperboard	38,105	401.8	15,309
Containerboard	23,563	373.1	8,790
Linerboard	16,177	380.5	6,155
Unbleached kraft	15,601	379.5	5,921
Solid bleached	170	496.3	84
Recycled	407	368.7	150
Corrugating material	7,351	357.0	2,625
Semichemical	5,528	358.2	1,980
Recycled	1,823	353.5	645
Container chip & filler	35	316.8	11
Recycled	35	316.8	11
Boxboard	7,014	511.7	3,589
Folding	5,292	483.4	2,558
Unbleached kraft	924	449.5	415
Solid bleached	2,016	616.7	1,243
Recycled	2,352	382.4	900
Set-up	279	391.4	109
Recycled	279	391.4	109
Milk carton & food service	1,443	638.7	921
Solid bleached	1,443	638.7	921
Other	4,396	353.5	1,554
Gypsum wallboard facing	1,182	322.7	381
Tube, can, & drum	1,411	302.0	426
Other	1,804	413.9	747
Exports	3,131	439.4	1,376
Unbleached kraft	2,296	375.7	863
Solid bleached	627	671.7	421
Semichemical	136	426.4	58
Recycled	72	470.7	34

Source: 1989 API Statistics of Paper, Paperboard, & Wood Pulp.

[a] Value per ton figures at the most detailed product category level are from corresponding product categories in Bureau of the Census (1989). For higher level categories, the value per ton is calculated as the sum of shipment values for all sub-categories divided by the sum of shipments.

Table 2.7
U.S. Imports, Exports, and Apparent Domestic Consumption
of Paperboard Products, by Type of Fiber, 1988
('000 Tons)

Product Category	Shipments [a]	Exports		Imports		Apparent Domestic Consumption [c]
		('000 Tons) [b]	as % of Shipments	('000 Tons) [b]	as % of Shipments	
All Paperboard	38,105	3,793	10.0%	345	0.9%	34,657
Unbleached Kraft	19,140	2,532	13.2%	86	0.4%	16,694
Semichemical	5,664	42	0.7%	142	2.5%	5,764
Bleached Kraft	4,511	924	20.5%	11	0.3%	3,598
Recycled	8,789	283	3.2%	101	1.2%	8,607
Wet Machine Board	120	12	9.7%	4	3.5%	113

[a] Source: 1989 API Statistics of Paper, Paperboard, & Wood Pulp.

[b] Source: 1989 Bureau of the Census, Current Industrial Reports; Pulp, Paper, and Board.

[c] Apparent Domestic Consumption represents Shipments plus Net Imports.

Apparent domestic consumption of all paperboard products, defined as domestic shipments plus net imports, totalled 34.7 million tons (U.S. Department of Commerce, 1990).

2.4 Overview of the Major Pulp, Paper, and Paperboard Producers

The types of pulp produced by the 20 largest U.S. pulp producers and the grades of paper and paperboard produced by the largest 25 paper and paperboard producers are described below. Information on the processes used at each mill operated by the 20 largest U.S. pulp producers was collected using the 1989 Lockwood-Post Directory and through industry consultants. In Table 2.8, production capacity by pulping process is presented for each company.

As seen in the table, the 20 largest U.S. producers own 74 bleached kraft mills. The kraft process is the dominant process in the industry, representing 77 percent of the capacity of the 20 largest U.S. pulp producers. This capacity is split relatively evenly between bleached (50,255 tpd) and unbleached (45,801 tpd) kraft processes. Overall, 38 percent of the capacity of these 20 producers is bleached kraft and 35 percent is unbleached kraft.⁶ The next largest processes are semichemical (5.3% of capacity), unbleached mechanical (4.8%), defibrated (4.1%), bleached sulfite (3.4%), and bleached mechanical (3.2%).

International Paper (IP) has the greatest capacity to pulp, at 14,938 tons per day. IP operates eleven bleached kraft mills with capacity of 8,438 tpd (56.5 percent of their total capacity) and five unbleached kraft mills with capacity of 3,888 tpd. Georgia-Pacific has the second greatest capacity, at 12,705 tpd. Georgia-Pacific operates five bleached kraft mills with capacity of 6,090 tpd (48% of total capacity) and three unbleached kraft mills with capacity of 3,600 tpd. Champion International has the sixth largest total pulping capacity, but the third largest in terms of bleached kraft capacity (5,465 tpd or 64 % of total capacity).

The third largest U.S. pulp producer, Stone Container, has total pulp capacity of 11,615 tpd. Of this, only 7.5 percent (875 tpd) is bleached kraft, while 81 percent is unbleached kraft. The only producer in the top 20 with no bleached kraft production is U.S. Gypsum, which uses the exploded, defibrated process to produce hardboard. Although alternatives to bleached kraft exist, Table 2.8 illustrates that, to date, the 20 largest U.S. pulp producers have not dedicated a significant percentage of their capacity to non-kraft bleached pulp..

Table 2.9 presents capacity by major product groupings of the 25 largest U.S. producers of paper and paperboard products. This information was compiled using the 1989 Lockwood-Post Directory of the Pulp, Paper and Allied Trades and the monthly grade reports

⁶For 5 percent of kraft capacity it was not possible to determine whether the capacity was for bleached or unbleached pulp.

Table 2.8
1988 Pulp Mill Capacity by Type of Mill - Top 20 U.S. Producers
(Tons Per Day)

Company	No. of Mills	Total Capacity	No. of Bleached Kraft Mills (d)	Kraft				Sulfite			Mechanical				
				Bleached	% Total Cap	Unbleached	Total (e)	Bleached	Unbleached	Semichem	Bleached	Unbleached	De-Inked	De-Fibrated	Other
1 International Paper (a)	23	14,838	11	8,438	56.6%	3,888	13,948	-	-	162	180	-	-	-	6800
2 Georgia-Pacific (b)	18	12,705	5	8,090	47.9%	3,600	9,690	800	-	600	-	825	280	1,010	-
3 Stone Container	13	11,615	3	875	7.5%	9,410	10,285	-	-	1,150	-	180	-	-	-
4 Weyerhaeuser Co.	17	9,505	6	2,815	29.6%	3,180	6,005	650	-	970	1,820	-	-	280	-
5 GNN (c)	13	10,829	4	3,184	29.4%	3,300	6,484	235	555	2,100	-	1,470	-	-	-
6 Champion Corp.	14	8,560	6	5,455	63.8%	1m700	7,155	-	-	-	385	1,010	-	-	-
7 Union Camp	4	7,770	2	1,950	25.1%	5,20	7,770	-	-	-	-	-	-	-	-
8 James River Corp.	15	6,268	6	3,238	51.6%	100	4,841	810	-	280	320	-	235	-	-
9 Westvaco Corp.	5	5,802	3	3,202	55.2%	2,600	5,802	-	-	-	-	-	-	-	-
10 Boise Cascade	15	5,628	6	1,780	31.8%	1,853	3,643	-	-	220	450	1,165	150	-	-
11 Jeff Smurfit/CCA	9	5,510	1	450	8.2%	3,610	4,060	-	-	200	-	950	300	-	-
12 Temple-Inland	5	5,370	0	1,520	28.3%	2,950	4,470	-	-	400	-	-	-	500	-
13 Bowater	5	3,984	2	1,350	34.1%	750	2,100	-	-	-	1,084	800	-	-	-
14 Scott Paper Co.	10	3,935	6	1,450	36.8%	0	2,850	835	-	-	-	-	250	-	-
15 USG	9	3,695	0	0	0.0%	0	0	-	-	-	-	135	-	3,560	-
16 Mead	7	3,225	3	1,200	37.2%	1,000	2,200	-	-	575	200	-	-	-	250
17 ITT Rayonier	4	3,225	4	1,725	53.5%	0	1,725	1,500	-	-	-	-	-	-	-
18 Federal Paper Board	3	3,200	2	3,200	100.0	0	3,200	-	-	-	-	-	-	-	-
19 Simpson Paper	7	2,875	4	1,815	62.2%	1,200	2,815	-	-	-	-	-	80	-	-
20 Willamette	5	2,605	1	700	26.9%	1,430	2,130	-	-	475	-	-	-	-	-
Total	209	131,222	74	50,255		45,801	101,181	4,430	555	7,002	4,189	6,335	1,275	5,330	930
Percent of Total		100.0%			38.3%	34.9%	77.1%	3.4%	0.4%	5.3%	3.2%	4.8%	1.0%	4.1%	0.7%

(a) Includes Hammermill

(b) Includes Brunswick Pulp & Paper

(c) Includes Leaf River Forest Products

(d) These mills use chlorine in the production of bleached kraft pulp, according to U.S. EPA, *The 104 Mill Study*, April 13, 1980.

(e) Totals for kraft include capacity for mills that did not indicate the amount of bleached versus unbleached capacity.

Source: Lockwood-Post's *Directory of the Pulp, Paper and Allied Trades*, 1988, and ERG industry estimates.

Table 2.9
Production Capacity of Largest U.S. Paper and Paperboard Products 1988
(000 Tons)

Rank	Company Name	Coated Free Sheet	Uncoated Free Sheet	Bleached Paperboard	Coated Groundwood	Uncoated Groundwood	Tissue	Kraft Paper	Kraft Linerboard	Recycled Paperboard	Paper Grade Chem Mkt Pulp	Newsprint	Corrugating Medium	Totals
1	International Paper Co.	[a]	2,100	835	645	--	--	280	1,850	--	820	--	370	6,880
2	Georgia-Pacific Corp.	--	1,970	3380	--	--	537	355	1,375	--	1,115	--	275	6,887
3	Stone Container	[a]	[a]	--	--	--	--	773	2,750	--	280	285	880	4,828
4	Weyerhaeuser Co.	180	807	220	--	--	--	--	1,530	--	550	504	690	4,481
5	Champion Corp.	285	1,114	247	689	239	--	185	240	--	270	858	--	4,137
6	GN Nekoosa	--	714	--	[a]	288	--	--	1,250	--	517	331	980	4,080
7	Jeff Smurfit/CCA Corp.	--	--	185	--	--	--	--	1,450	1,330	--	580	390	3,935
8	James River Corp.	252	872	235 [b]	315	[a]	1,111	150	223	--	110 [b]	--	--	3,268
9	Boise Cascade Corp.	270 [b]	910	--	390	270	36	[a]	23 [b]	--	245	577	110	2,831
10	Union Camp Corp.	--	800	140	--	--	--	350	1,350	--	--	--	--	2,840
11	Westvaco Corp.	580	200	820	--	--	--	--	800	--	108	--	[a]	2,308
12	Mead Corp.	380	520	--	335	--	--	--	396	--	108	--	390	2,129
13	Scott Paper Co.	800	[a]	--	--	--	1,050	--	--	--	108	--	--	2,058
14	Temple-Inland	--	--	357	--	--	--	--	1,235	--	[a]	--	210	1,802
15	Bowater	--	--	--	330	--	--	--	--	--	255	1,039	--	1,824
16	P&G Buckeye Cellulose	--	--	--	--	--	900	--	--	--	870	--	--	1,670
17	Kimberley-Clark	--	80	--	--	--	680	--	--	--	240	419	--	1,419
18	Willamette	--	180	--	--	--	--	70	800	--	252	--	--	1,302
19	Packaging Corp.	--	--	--	--	--	--	--	800	210	--	--	280	1,290
20	Abitibi-Price Inc.	102	--	--	--	525	--	--	180	--	--	385	--	1,192
21	Simpson Paper	280	450	--	--	--	--	[a]	[a]	--	420	--	--	1,180
22	Federal Paper Board	[a]	--	631	--	--	--	--	--	--	480	--	--	1,091
23	Potlatch Corp.	300	--	554	--	--	70	--	--	--	--	--	--	924
24	U.S. Gypsum	--	--	--	--	--	--	-- [b]	532	332	--	--	--	864
25	Fort Howard	--	--	--	--	--	850	--	--	--	--	--	--	850

[a] Production indicated, but quantity not specified.

[b] Additional mills indicated production, but did not specify quantity.

-- no production volume reported.

Note: Rankings were made by ERG according to production volumes reported in the sources listed. Additions, unreported production may exist which would affect total volumes and rankings.

Source: *Pulp & Paper Magazine*, August 1989 to July 1990.

Lockwood-Post's Directory of the Pulp, Paper and Allied Trades, 1989.

in Pulp & Paper Magazine from August 1989 through July 1990. Rankings were made according to capacity reported in the sources noted above.⁷

Each month, Pulp & Paper Magazine (1989, 1990) publishes a grade profile listing the top 10 U.S. producers for a specific grade of paper or paperboard. This data was compiled for each of the 12 major paper and paperboard grades and used to rank companies in order of their total capacity, i.e. across all 12 grade categories. The capacity figures from Pulp and Paper were supplemented with information from Lockwood-Post's Directory to fill in additional capacity information for these companies. It must be noted, however, that Lockwood-Post's listings for mills operated by these companies often indicate the products which are produced without providing information on volumes. The rankings by total volume in Table 2.9 are based only on capacity volumes which could be identified through these two sources.

This compilation of capacity data, as seen in Table 2.9, indicates that IP has potential to be the largest overall producer, with significant production of bleached paperboard, coated groundwood, uncoated free-sheet, kraft linerboard, kraft paper, corrugating medium, and paper grade chemical market pulp. IP's total reported capacity was 7.0 million tons in 1988. According to the 1989 Lockwood-Post's directory, IP operates 23 pulp and paper mills in the U.S. The other large producers include Georgia-Pacific (6.0 million tons; 25 mills), Stone Container (4.9 million tons; 13 mills), Weyerhaeuser (4.5 million tons; 17 mills), and Champion Corporation (4.1 million tons; 14 mills).

2.5 Bleached Paper Products

This section addresses the amount of bleached pulp utilized in the manufacture of various grades of paper and paperboard. It first provides an overview of the fibrous and non-fibrous materials which go into making paper and paperboard, then addresses the issue of recycled fiber utilization in the paper and board making process. Estimates of the bleached pulp content of paper and paperboard grades are then presented.

2.5.1 Fibrous and Nonfibrous Materials Used in Paper and Paperboard Making

Paper and paperboard products are generally made from a mix of both fibrous and non-fibrous materials. Collectively, the materials which are blended to produce a grade of paper or paperboard are referred to as the "furnish". In addition to fibrous material (pulp or a mix of pulps), the furnish may contain any of the following: nonfibrous fillers such as clay, used to improve the smoothness and brightness of the paper; sizing agents, which affect surface characteristics such as creasability or abrasion resistance; wet-strength or other additives; and

⁷According to these sources, unreported production exists in some cases which affects total volumes and rankings.

dyes. These non-fibrous additives may constitute up to 40 percent of the furnish weight; in most grades additives average less than 10-15 percent.

The fibrous component of the furnish generally consists of wood pulp or a mix of wood pulps, as well as secondary or recycled fibers, if they are used. Most grades utilize a mix of pulps in order to obtain the desired properties of the paper or board. Typical pulps for newsprint, for example, consist of 75 percent mechanical and 25 percent chemical fibers.

Scrap paper (i.e., any paper that could be reprocessed), has become an important source of fiber for some grades of paper. The amount of scrap paper used in the manufacture of a grade of paper, as a percent of total production of that grade, is referred to as the scrap paper utilization rate. This rate varies depending upon the grade of paper or board. The highest rates are for recycled paperboard (100%), tissue (44%), and newsprint (23%), while rates for most printing and writing papers are below 10 percent. When blended with virgin pulp, recycled materials are processed separately using mechanical means to separate the fibers and filter out foreign materials. For most tissue and writing papers, the recycled fibers also go through a de-inking process. (In addition to removing ink from the fibers, the term "de-inking" covers other cleaning and purifying processes that may be required). Recycled fibers may also go through a bleaching or coloring process, depending upon (1) whether they are originally from bleached paper or board grades, and (2) the degree of whiteness desired in the final product. In general, however, recycled fibers are not subjected to the chlorine bleaching processes used for virgin fibers.

Paper manufacturers tend to utilize scrap paper which is similar in furnish to the final products they are making. (Mixed paper is generally used to manufacture the lowest grade of paper in the mix.) Thus, corrugated scrap paper is recycled into corrugating medium, scrap business paper is used in producing recycled printing and writing paper, and old newspapers are recycled into newsprint. The secondary fibers used in paper and boardmaking can be expected, therefore, to have approximately the same furnish as the virgin fibers with which they are being blended. An investigation of the bleached pulp content of various grades of paper and paperboard based only on virgin fibers might understate, therefore, the amount of bleached fibers contained in the final product. To the extent possible, information on the amount of bleached secondary fibers present in the various grades of paper and board has been incorporated in the analysis which follows.

2.5.2 Pulp Types Used in Various Grades of Paper and Paperboard

This analysis develops estimates of the total fiber content of a variety of paper and paperboard grades, as well as the percent of all fiber which is from virgin bleached pulp. Data came partially from the 1987 risk assessment for bleached kraft paper products completed for EPA (Arthur D. Little, 1987), with the remainder from Eastern Research Group (ERG). ERG

developed their estimates based on discussions with industry specialists from the U.S. Forest Service, Department of Commerce, and academia.⁸

Table 2.10 presents the analysis of the fiber and bleached pulp components of a number of paper and paperboard grades. The grades shown are those for which estimates were available or could be accurately developed. While estimates at a more detailed product level would be desirable, this data is not currently available.

Columns in the table present a variety of data items and estimates. From left to right, these are:

- (a) 1988 shipment volumes for paper and paperboard categories.
- (b) The amount of fiber contained in the overall furnish. This indicates the percentage of the final blend of slurried materials which is processed into paper by pulp and paper mills that is fiber, as opposed to other materials such as fillers, agents, dyes, etc. These percentages were largely developed for this analysis from published sources and discussions with industry observers.
- (c) The amount of total fiber (in thousands of tons) which is assumed to be contained in the final product. This is the product of the shipment volume of a particular grade of paper or board and the percent of the furnish which is estimated to be fiber. Fiber and furnish quantities are often expressed on an oven-dry basis (zero water content), and this is the assumption made here. Hence a ton of paper or board is assumed to be produced from a ton of furnish.
- (d) Bleached virgin kraft pulp as a percent of total fiber. This represents the estimate of the percent of all fiber which goes into the furnish which is from bleached virgin kraft pulp. Some of these estimates, as noted, are from the 1987 risk assessment for bleached kraft paper products (Arthur D. Little, 1987), while the remainder were developed for this report.
- (e) The amount of virgin bleached fiber which is assumed to be contained in the final product. This is the product of the estimated fiber usage (column c) and the estimate of the percent of that fiber which is from bleached virgin pulp.

⁸It should be noted that the American Paper Institute (API) has conducted surveys as recently as 1986 which would provide more complete data on this subject. API declined to make these survey results available since they felt they were out of date. In mid 1990, API reported that they intended to conduct another survey in late 1990 and that they will make the data from that survey available to the public.

Table 2.10
Estimates of Bleached Kraft Pulp and Other Fiber Usage
for Various Paper and Paperboard Grades

Grade [a]	1988 Shipments '000 tons	Percent Fiber in Furnish [b]	Implicit Fiber Usage [c] '000 tons	Bleached Virgin Kraft Pulp as a % of Total Fiber	Implicit Bleached Virgin Kraft Pulp Usage [c] '000 tons	Recycled Bleached Kraft Fiber as a Percent of Total Fiber (maximum) [d][e]	Source of Percent Bleached Kraft Estimate [f][g][h]	Other Fibers [i]
Newsprint	5,982	100.0%	5,982	20.0%	1,196	4.8%	ERG	TMP (30%), Groundwood (25%), Other recycled (20%)
Uncoated groundwood	1,624	90.0%	1,461	20.0%	292	6.3%	ERG	Groundwood (45%), TMP, Sulfite
Coated groundwood	4,262	60.0%	2,557	50.0%	1,279	6.3%	ERG	Groundwood (20%), TMP
Coated free sheet	3,349	70.0%	2,344	90.0%	2,110	6.3%	ERG	none
Uncoated free sheet	11,277	80.0%	9,022	80.0%	7,217	6.3%	ERG	Sulfite (5%)
Bond & writing	2953	80.0%	2,362	80.0%	1,890	6.3%	ERG	Sulfite (5%)
Form bond	2127	80.0%	1,702	80.0%	1,361	6.3%	ERG	Sulfite (5%)
Ledger	41	80.0%	33	80.0%	26	6.3%	ERG	Sulfite (5%)
Mimeograph	28	80.0%	22	80.0%	18	6.3%	ERG	Sulfite (5%)
Duplicating	45	80.0%	36	80.0%	29	6.3%	ERG	Sulfite (5%)
Papaterie & wedding	40	80.0%	32	80.0%	26	6.3%	ERG	Sulfite (5%)
Carbonless	684	80.0%	547	80.0%	438	6.3%	ERG	Sulfite (5%)
Cover & text papers	349	80.0%	279	80.0%	223	6.3%	ERG	Sulfite (5%)
M.F., E.F., & supercalendered	86	80.0%	69	80.0%	55	6.3%	ERG	Sulfite (5%)
Offset	2918	80.0%	2,334	80.0%	1,868	6.3%	ERG	Sulfite (5%)
White wove envelope	942	80.0%	754	80.0%	603	6.3%	ERG	Sulfite (5%)
Tablet	379	80.0%	303	80.0%	243	6.3%	ERG	Sulfite (5%)
Thin papers	217	100.0%	217	90.0%	195	6.3%	ERG	Unbleached kraft
Cotton fiber	167	90.0%	150	30.0%	45	6.3%	ERG	Sulfite
Bleached bostols	1,150	90.0%	1,035	90.0%	931	6.3%	ADL/ERG	Sulfite, Semichemical
Tabulating Index	40	90.0%	36	90.0%	32	6.3%	ADL/ERG	Sulfite, Semichemical
Tag	185	90.0%	167	90.0%	150	6.3%	ADL/ERG	Sulfite, Semichemical
File folder	214	90.0%	193	90.0%	173	6.3%	ADL/ERG	Sulfite, Semichemical
Index bostol	153	90.0%	138	90.0%	124	6.3%	ADL/ERG	Sulfite, Semichemical
Printing bostol	67	90.0%	60	90.0%	54	6.3%	ADL/ERG	Sulfite, Semichemical
Coated bostol	488	90.0%	439	90.0%	395	6.3%	ADL/ERG	Sulfite, Semichemical

TABLE 2.10 (Cont.)
Estimates of Bleached Kraft Pulp and Other Fiber Usage
for Various Paper and Paperboard Grades

Grade [a]	1988 Shipments '000 tons	Percent Fiber in Furnish [b]	Implicit Fiber Usage [c] '000 tons	Bleached Virgin Kraft Pulp as a % of Total Fiber	Implicit Bleached Virgin Kraft Pulp Usage [c] '000 tons	Recycled Bleached Kraft Fiber as a Percent of Total Fiber (maximum) [d][e]	Source of Percent Bleached Kraft Estimate [f][g][h]	Other Fibers [i]
Unbleached kraft packaging & industrial papers	3,861	100.0%	3,861	0.0%	0	0.6%	ERG	Unbleached kraft (90%)
Bleached packaging papers [j]	465	95.0%	442	90.0%	398	3.0%	ADL/ERG	Sulfite, Unbleached kraft
Wrapping	24	95.0%	23	90.0%	21	3.0%	ADL/ERG	Sulfite, Unbleached kraft
Bag and sack	262	95.0%	248	90.0%	224	3.0%	ADL/ERG	Sulfite, Unbleached kraft
Shipping sack	111	95.0%	105	90.0%	85	3.0%	ADL/ERG	Sulfite, Unbleached kraft
Other converting	69	95.0%	66	90.0%	59	3.0%	ADL/ERG	Sulfite, Unbleached kraft
Specialty packaging	596	95.0%	566	90.0%	510	3.0%	ADL/ERG	Sulfite, Unbleached kraft
Special industrial papers	1,186	95.0%	1,127	50.0%	563	3.0%	ERG	Sulfite, Groundwood, TMP
Tissue	5,476	100.0%	5,476	50.0%	2,738	31.1%	ERG	Sulfite (10%), Unbleached kraft, TMP
Toilet	2,032	100.0%	2,032	50.0%	1,016	31.1%	ERG	Sulfite (10%), Unbleached kraft, TMP
Facial	351	100.0%	351	50.0%	176	31.1%	ERG	Sulfite (10%), Unbleached kraft, TMP
Napkins	697	100.0%	697	50.0%	349	31.1%	ERG	Sulfite (10%), Unbleached kraft, TMP
Towelling	1,863	100.0%	1,863	50.0%	932	31.1%	ERG	Sulfite (10%), Unbleached kraft, TMP
Other sanitary tissue	383	100.0%	383	50.0%	192	31.1%	ERG	Sulfite (10%), Unbleached kraft, TMP
All other tissue	194	100.0%	194	50.0%	97	31.1%	ERG	Sulfite (10%), Unbleached kraft, TMP
Unbleached kraft paperboard	19,140	100.0%	19,140	0.0%	0	0.6%	ERG	Other recycled (10%), Semichemical
Solid bleached paperboard	4,511	90.0%	4,060	80.0%	3,248	0.6%	ADL/ERG	Recycled, Groundwood
Linerboard	170	90.0%	153	90.0%	138	0.6%	ADL/ERG	Recycled, Groundwood
Folding carton type board	2,016	90.0%	1,815	80.0%	1,452	0.6%	ADL/ERG	Recycled, Groundwood
Milk carton & food service	1,443	90.0%	1,298	75.0%	974	0.6%	ADL/ERG	Groundwood
Other	255	90.0%	229	80.0%	184	0.6%	ADL/ERG	Recycled, Groundwood
Exports	627	90.0%	565	80.0%	452	0.6%	ADL/ERG	Recycled, Groundwood
Semichemical paperboard	5,664	100.0%	5,664	0.0%	0	1.6%	ERG	Semichemical (70%), Other recycled (25%), Unbleached kraft
Recycled paperboard	8,789	95.0%	8,350	0.0%	0	26.5%	ERG	Recycled (70%)

Notes to Table 2.10

[a] These are grades for which estimates of fiber and bleached pulp content are available. This list is not comprehensive and is not designed to account for all bleached pulp produced or consumed in the United States.

[b] The term "furnish" refers to the blend of fibrous and nonfibrous materials which are used in the papermaking process. In addition to fiber (pulp), some grades of paper may contain substantial quantities of fillers, additives, dyes, etc.

[c] Tons are as measured on an oven-dry basis (zero water content).

[d] Includes the following grades of wastepaper: high grade deinking, mixed grades, and pulp substitutes. Excludes newspaper and corrugated grades. The grades included are those which potentially would have gone through chlorine bleaching. Secondary fibers, from both bleached and unbleached stock, may also be bleached (or re-bleached) prior to blending with virgin fibers. Data describing treatment of secondary fibers is not readily available, however bleaching processes for secondary fibers generally do not involve chlorine.

[e] Utilization rates are available for the following end-use categories only: newsprint; printing, writing, & related; packaging & industrial converting paper; tissue; unbleached & bleached kraft paperboard; semichemical paperboard; and recycled paperboard.

[f] Some of the ADL estimates give a range for bleached pulp content; the midpoint is presented here.

[g] ADL estimates are based on 1987 fiber furnish estimates.

[h] ERG estimates are based on 1989 fiber furnish estimates. ERG subtracted the percent of bleached recycled fiber from the ADL estimates where this was appropriate.

[i] Where no percentages are given, percent is estimated at below 5%.

[j] Includes semibleached packaging.

Sources:

American Paper Institute. 1989 Statistics of Paper, Paperboard, & Wood Pulp.

American Paper Institute. Paper Recycling Committee. 1989 Annual Statistical Summary of Waste Paper Utilization.

A.D. Little, Inc. Exposure and Risk Assess. of Dioxin in Bleached Kraft Paper Products. U.S. EPA Contract 68-01-6951. June 25, 1987.

ERG estimates, based upon industry consultants and other industry sources.

- (f) Estimate of the percent of total fiber in the furnish which is from recycled bleached sources. Many grades of paper and paperboard are manufactured with significant quantities of recycled or secondary fibers. The use of scrap paper can be an additional source of bleached fibers for these grades if the fibers are either from bleached scrap paper products or if they are bleached (or re-bleached) prior to being mixed in with the virgin fiber in the pulp. While the percent of total fiber which was from bleached scrap paper products was estimated for this analysis, it was not possible to estimate the amount which is bleached or re-bleached prior to use.

The table indicates that the estimate of recycled bleached fiber is a maximum. As indicated in footnote [d], the estimate is based on the combined percentage of fiber which is from high grade deinking, mixed grades, and pulp substitute grades of scrap paper. These grades may be assumed to contain varying amounts of bleached paper or board.

- (g) The source of the estimate of the percent of total fiber which is from virgin bleached kraft pulps. These estimates are based partly on the 1987 risk assessment for bleached kraft paper products and partly upon original investigations performed for this report.
- (h) Additional fiber types used in the manufacture of each grade of paper. The percentages, where given, indicate the percent of total fiber represented by each fiber type. Where no percentages are given, the percentages are estimated at below 5 percent.

2.5.3 Percentage of Bleached Pulp in Various Paper and Paperboard Grades

As seen below, the various grades of paper and paperboard can be classified into three groups according to their bleached pulp content. These are:

High bleached pulp content (75-90 percent of total fiber)

- Coated and uncoated free sheet
- Thin papers
- Bleached bristols
- Various grades of bleached packaging papers
- Various grades of solid bleached paperboard

Medium bleached pulp content (30-75 percent of total fiber)

- Coated groundwood
- Special industrial papers
- All grades of tissue (an additional 30-40 percent is from recycled bleached fiber)

Low bleached pulp content (0-30 percent of total fiber)

- Newsprint
- Cotton fiber papers
- Unbleached kraft packaging paper
- Unbleached kraft paperboard
- Semichemical paperboard
- Recycled paperboard

In the sections below, paper and board grades classified in either the high or medium pulp content categories are examined in detail.⁹

2.5.4 Paper and Paperboard Grades with High Bleached Pulp Content.

Among the paper and paperboard grades shown above to be formulated with a high percentage of virgin bleached pulp fibers, some categories include high volume, everyday use products, while others represent relatively specialized product groups. Each of the high bleached pulp content grades is examined below.

Uncoated and coated free sheet. Uncoated free sheet represents the highest volume category classified as having a high bleached virgin pulp content. In the aggregate, this category is estimated to contain approximately 80 percent fiber, of which 80 percent is bleached virgin pulp. A large number of common business, commercial, and consumer papers are classified as uncoated free sheet. Examples include, in order of 1988 shipment volume (see Table 2.11):

- Bond and writing paper (26% of all uncoated free sheet);
- Paper used in offset printing (25%);
- Form bond, used for printed business forms (19%);
- White wove envelope (8%);
- Carbonless paper, also used for business forms (6%)
- Tablet paper (3%).

The table shows data on shipments volume for the different categories of uncoated free sheet over the period 1963-88. As before, comparisons will be made between grades over the 1973-88 period, since consistent data for paperboard products back to 1963 has not been developed. During 1973-88, shipments of all uncoated freesheet grades increased from 6.7 million to 11.3 million tons, an increase of 69 percent. Shipments of bond and writing paper and form bond paper grew at considerably higher rates, 175 and 90 percent respectively. Offset grade, the other large category of uncoated free sheet, grew by 57 percent. Shipments of several other grades, including ledger, mimeo, duplicating, manifold, papeterie and wedding, machine finish, English finish, and supercalendar, decreased over this period.

⁹Appendix 2.C presents additional data on the number of mills which produce in the high and medium bleached pulp content product categories.

Table 2.11
Shipments of Uncoated and Coated Free Sheet Grades 1963-1988
Selected Years
('000 Tons)

Grade	1963	% change 1963-68	1968	% change 1968-73	1973	% change 1973-78	1978	% change 1978-83	1983	% change 1983-88	1988	% change 1963-88	% change 1973-88
Uncoated free sheet	3,634.1	31.7%	4,787.7	39.4%	6,673.6	7.9%	7,202.0	21.2%	8,725.7	29.2%	11,277.0	210.3%	69.0%
Bond & writing	470.0	33.4%	627.1	71.4%	1,075.0	32.5%	1,424.7	44.4%	2,057.3	43.5%	2,953.1	528.3%	174.7%
Form bond	375.0	52.2%	570.9	96.2%	1,119.9	18.8%	1,330.5	26.8%	1,687.5	26.1%	2,127.3	467.3%	90.0%
Ledger	45.1	21.1%	54.6	13.6%	62.0	-6.9%	57.7	-10.9%	51.4	-19.3%	41.5	-8.0%	-33.1%
Mimeograph	110.9	21.6%	134.9	6.2%	143.3	-35.9%	91.9	-39.2%	55.9	-49.4%	28.3	-74.5%	-80.3%
Duplicating	116.0	38.7%	160.9	13.4%	182.4	-18.0%	149.5	-11.6%	132.1	-65.9%	45.0	-61.2%	-75.3%
Manifold	17.4	-19.5%	14.0	-9.3%	12.7	-4.7%	12.1	-76.0%	2.9	-55.2%	1.3	-92.5%	-89.8%
Papeterie & wedding	42.9	30.5%	56.0	2.3%	57.3	-14.1%	49.2	-21.3%	38.7	2.8%	39.8	-7.2%	-30.5%
Carbonless	NA	-	50.0	140.0%	120.0	108.3%	250.0	60.0%	400.0	71.1%	684.4	-	470.3%
Opaque circular	27.3	-14.7%	23.3	44.2%	33.6	17.9%	39.6	-	NA	-	NA	-	-
Other	247.6	-	NA	-	NA	-	NA	-	NA	-	NA	-	-
Cover & text papers	155.4	24.1%	192.8	13.8%	219.5	-3.4%	212.1	30.1%	276.0	26.3%	348.6	124.3%	58.8%
M.F., E.F., & supercalendered	264.1	-25.0%	198.2	-22.0%	154.6	-55.0%	69.5	25.9%	87.5	-1.7%	86.0	-67.4%	-44.4%
Offset	862.3	50.2%	1,295.4	43.8%	1,862.5	3.1%	1,920.2	15.1%	2,209.8	32.0%	2,917.9	238.4%	56.7%
White wove envelope	318.8	44.2%	459.6	24.2%	570.9	3.7%	592.3	20.7%	715.1	31.8%	942.5	195.6%	65.1%
Tablet	281.5	11.2%	313.0	-2.4%	305.5	14.7%	350.4	15.9%	406.1	-6.8%	378.6	34.5%	23.9%
Kraft envelope papers	175.2	6.5%	186.6	14.7%	214.0	7.6%	230.2	0.2%	230.7	16.6%	268.9	53.5%	25.7%
Brown kraft (est.)	85.0	7.5%	91.4	16.7%	106.7	13.5%	121.1	-5.7%	114.2	26.4%	144.3	69.8%	35.2%
Bleached kraft (est.)	90.2	5.5%	95.2	12.7%	107.3	1.7%	109.1	6.8%	116.5	7.0%	124.6	38.1%	16.1%
Other	124.6	261.5%	450.4	20.0%	540.4	-21.9%	422.1	-11.2%	374.7	10.4%	413.8	232.1%	-23.4%
Coated Free Sheet [a]	1,115.6	27.8%	1,426.2	21.9%	1,738.4	16.4%	2,024.0	29.9%	2,629.3	31.9%	3,467.9	210.9%	99.5%

Note [a] API reports figures for all coated papers only. Census data indicates that in 1988 free sheet accounted for 46% of all coated paper. This percentage has been used to estimate shipments of coated free sheet for 1963-88. ERG will develop further estimates of shipments of coated free sheet for its final report.

Source: 1989 API Statistics of Paper, Paperboard, & Wood Pulp.

Coated free sheet is generally reported as a single category of paper. In fact, the API data on which most of this analysis is based does not differentiate between coated free sheet and coated groundwood papers; a single figure for "coated papers" is reported. This distinction is made, however, in the Bureau of the Census Report on Pulp, Paper, and Board (1989). In the most recent report, free sheet accounts for approximately 46 percent of all coated paper shipments. Shipments of coated free sheet have increased from 1.7 million to 3.5 million tons over the period 1973-88. This amounts to a near doubling in volume, compared to a 69 percent increase for uncoated free sheet over the same period. As previously indicated, coated free sheet is used mainly in commercial printing for high quality advertising, brochures, magazines, and books. Coated free sheet is estimated to contain 70 percent fiber, of which 90 percent is estimated to be virgin bleached wood pulp fiber.

The increase in demand for printing/writing papers has been largely a function of the surge in paper used by businesses, primarily for office copying and duplicating. Writing papers are also consumed in business forms and computer print-outs. While it was anticipated that the age of electronic data processing would decrease the demand for paper, the expanded quantity of data that is analyzed has resulted in more paper use.

Thin papers. Thin papers include lightweight papers such as carbon paper, cigarette paper, condenser paper, and paper used in printing Bibles. Tissue paper is not included in this category. These papers are estimated to contain close to 100 percent fiber, of which 90 percent is virgin wood pulp fiber.

Shipments data are generally reported only for the entire category of thin papers; data for particular product categories described above are not available. Between 1973 and 1988, shipments of thin papers decreased, falling from 358 thousand to 216 thousand tons. This represented a decrease of close to 40 percent (see Table 2.12). Undoubtedly this decline is related to the reduced demand for carbon paper in the office market as well as a reduced smoker demand for cigarette papers.

Bleached Bristols. Solid bleached bristols are estimated to contain an average of 90 percent fiber, of which 90 percent is virgin bleached fiber. Compared with uncoated free sheet or even particular grades such as bond and writing, form bond, or offset, bristols are a relatively low volume category of product. In 1988, shipments of all bristol grades totaled 1.1 million tons. This represented only 3 percent of all paper products shipments. Examples of bleached bristol grades, in order of 1988 shipments volume, are:

- Coated bristol, used for poster board and postcards (42 % of all bleached bristols);
- File folder, used in manila and other types of folders (19%);
- Tag stock, used for making tags of all types (13%);
- Printing bristol, used for printing purposes (6%);
- Tabulating index, used for computer cards, but declining rapidly in significance (3%).

As seen in Table 2.13, shipments of all bristols grew from 870 thousand tons in 1963 to 1.25 million tons in 1973, but have since fallen to 1.1 million tons in 1988, the most recent year for which data are available. Nevertheless, the two largest volume bristol grades, coated bristol

Table 2.12
Shipments of Thin Paper Grades, 1963-1988
Selected Years
('000 Tons)

Year	Shipments	Period	% change
1963	178.7	1963-68	46.4%
1968	261.6	1968-73	36.9%
1973	358.2	1973-78	-1.8%
1978	351.7	1978-83	-16.9%
1983	292.4	1983-88	-26.0%
1988	216.5		
		1963-88	21.2%
		1973-88	-39.6%

Source: API 1989 Statistics of Paper, Paperboard, & Wood Pulp.

Table 2.13
Shipments of Bleached Bristol Grades 1963-1988
Selected Years
('000 Tons)

Grade	1963	% change 1963-68	1968	% change 1968-73	1973	% change 1973-78	1978	% change 1978-83	1983	% change 1983-88	1988	% change 1963-88	% change 1973-88
Bleached bristol	870.3	28.4%	1,117.4	12.4%	1,255.7	-10.3%	1,126.3	-14.1%	967.3	18.8%	1,149.5	32.1%	-8.5%
Tabulating index	395.5	35.2%	534.6	-8.1%	491.2	-36.8%	310.6	-65.6%	106.7	-62.5%	40.0	-89.9%	-91.9%
Tag	164.7	23.7%	203.7	8.1%	220.3	-5.7%	207.7	-8.1%	190.9	-3.0%	185.1	12.4%	-16.0%
File folder	58.9	32.1%	77.8	12.0%	87.1	28.9%	112.3	28.9%	144.8	47.4%	213.5	262.5%	145.1%
Index bristol	98.0	6.5%	104.4	25.4%	130.9	9.5%	143.4	-1.7%	140.9	8.4%	152.7	55.8%	16.7%
Printing bristol	22.3	7.6%	24.0	95.4%	46.9	9.4%	51.3	8.0%	55.4	21.7%	67.4	202.2%	43.7%
Postcard	13.7	-62.0%	5.2	-40.4%	3.1	-80.6%	0.6	216.7%	1.9	68.4%	3.2	-76.6%	3.2%
Coated bristol	117.2	43.1%	167.7	64.7%	276.2	8.8%	300.4	8.8%	326.7	49.3%	487.6	316.0%	76.5%

Source: API 1989 Statistics of Paper, Paperboard, & Wood Pulp.

and file folder, have increased in volume since 1973. Shipments of coated bristols increased from 276 thousand tons in 1973 to 488 thousand tons in 1988, an increase of 77 percent, while file folder grades increased from 87 thousand to 214 thousand tons for an increase of 145 percent. The most dramatic decrease has been, as mentioned, in the tabulating index grade. In 1973 shipments of this grade totalled 491 thousand tons and accounted for 39 percent of all bleached bristols. In 1988, only 40 thousand tons, representing 3.5 percent of all bristols, were produced.

Bleached Packaging Papers. The bleached packaging paper category includes a list of products which is analogous to that for unbleached packaging, i.e., wrapping, bag and sack, shipping sack, and other converting. While unbleached products dominate these categories, about 17 percent of total production is from bleached pulps. These are generally more expensive than their unbleached counterparts and are used to enhance the appearance of the final product.

In Table 2.14, shipments of all bleached packaging papers are seen to have increased from 782 thousand tons in 1963 to 1,115 thousand tons in 1978, but the volume had declined to 465 thousand tons by 1988. It should be noted, however, that API revised several of these data series in 1981. Apparent reductions in shipments may be more a result of this reclassification than of actual industry conditions. However, it is likely that paper packaging will face continued strong competition from plastic, as well as from the growth of bulk shipping requiring no bags or containers.

Bleached Paperboard. As seen in Table 2.15, shipments of bleached paperboard grades totaled 3.8 million tons. This represented 10 percent of all paperboard shipments. Bleached paperboard products fall into one of four main subcategories. Listed in order of 1988 shipment volume, these are:

- Folding boxboard. These are boxes which are set up, filled, and closed by the end user. Examples include gift boxes utilized by department and specialty stores. In 1988, these accounted for 52 percent of all bleached paperboard product shipments;
- Milk carton and food service. Includes board used for milk carton and other liquid beverages as well as board used for other food items such as butter and ice cream. These grades accounted for 37 percent of bleached paperboard shipments in 1988;
- Other bleached paperboard grades (7%);
- Linerboard, used as the facing material in corrugated or solid fiber shipping containers (4%).

Shipments of bleached paperboard products have increased only slightly over 1973-88, from 3.5 million to 3.8 million tons. Highest growth has been in the miscellaneous category,

Table 2.14
Shipments of Bleached Packaging Papers 1963-1988
Selected Years
('000 Tons)

TYPE OF PRODUCT	1963	% change 1963-68	1968	% change 1968-73	1973	% change 1973-78	1978	% change 1978-83	1983	% change 1983-88	1988	% change 1963-88	% change 1973-88
Bleached packaging papers	782.0	20.6%	942.9	-8.0%	867.0	28.6%	1,115.2	-61.5%	429.3	8.3%	465.0	-40.5%	-46.4%
Wrapping	191.4	10.0%	210.5	-24.9%	158.1	-2.5%	154.2	-79.8%	31.1	-22.5%	24.1	-87.4%	-84.8%
Bag & sack (exc. shipping sack)	130.4	59.4%	207.8	22.3%	254.2	8.9%	276.7	-14.9%	235.6	11.0%	261.5	100.5%	2.9%
Shipping sack	67.0	32.4%	88.7	17.7%	104.4	-12.3%	91.6	-3.4%	88.5	25.0%	110.6	65.1%	5.9%
Other converting	393.2	10.8%	435.8	-19.6%	350.4	69.1%	592.7	-87.5%	74.1	-7.2%	68.8	-82.5%	-80.4%

Source: API 1989 Statistics of Paper, Paperboard, & Wood Pulp.

Table 2.15

Shipments of Bleached Paperboard Grades, 1973-1988
Selected Years
('000 Tons)

Grade	1973	% change 1973-78	1978	% change 1978-83	1983	% change 1983-88	1988	% change 1973-88
Bleached paperboard	3,561	-1.1%	3,522	-4.0%	3,380	14.9%	3,884	9.1%
Linerboard	128	-9.4%	116	-0.6%	115	47.7%	170	33.0%
Folding boxboard	1,706	2.0%	1,740	-2.6%	1,694	19.0%	2,016	18.2%
Milk carton & food service	1,594	-9.3%	1,446	-6.1%	1,359	6.2%	1,443	-9.5%
Other	134	65.2%	221	-3.4%	213	19.7%	255	90.9%

Source: 1989 API Statistics of Paper, Paperboard, & Wood Pulp.

which has increased from 134 thousand to 255 thousand tons over this period. The largest volume category, folding boxboard, increased from 1.7 million to 2.0 million tons, for an increase of 18 percent. The moderate growth rate of folding boxboard may be due to the saturation of supermarket packaging and, also, to increased competition from plastic containers and flexible packaging. Similarly, milk cartons/food service board must compete with plastic and glass alternatives.

2.5.5 Paper and Paperboard Grades with Medium Bleached Pulp Content

The following paper and paperboard grades are estimated to contain a medium range of virgin bleached pulp content (30-50 percent of total fiber).

Coated groundwood. As indicated above, API data sources report shipments for all coated papers together, regardless of type. In this report, it is assumed that 46 percent of all coated paper is coated free sheet and that the remainder (54 percent) is coated groundwood paper.

Coated groundwood is commonly used for printing magazines, directories, and advertising materials; demand for coated groundwood therefore depends on the circulation of these materials. Shipments of these papers have grown from 2.0 million to 3.9 million tons over the period 1973-88, for an increase of 95 percent (see Table 2.16). Coated groundwood is estimated to contain approximately 60 percent fiber, of which 50 percent is virgin bleached pulp.

Special Industrial Papers. Industrial papers are described in the Dictionary of Paper (API, 1980) as "Papers intended for industrial uses, as opposed to those for cultural or sanitary purposes". Although a range of paper types is likely to be represented here, shipments data is reported only for the main category. As was the case for bleached packaging paper, API revised their definitions for this category in 1981, with the result that shipments trends reported in the data are related only partly to actual industry occurrences.

According to available data, shipments in 1973 were 650 thousand tons. By 1988, over 1.1 million tons of papers classified in this group were shipped (see Table 2.17).

Tissue. Tissue papers as a class contain close to 100 percent fiber, of which approximately 50 percent is estimated to be from virgin bleached wood pulp. An additional 30-40 percent, however, is from bleached scrap paper sources, hence the bleached fiber content of tissue is actually closer to 90 percent.

In 1988, shipments of all tissue grades totalled 5.5 million tons (see Table 2.18), representing 14 percent of all paper products. Over 95 percent of tissue is used in manufacturing sanitary products. The non-sanitary grades include wrapping, waxing, and creped. The main tissue products groups, in order of 1988 shipments volume, are:

Table 2.16
Shipments of Coated Groundwood Grades, 1963-1988
Selected Years
('000 Tons)

Year	Shipments [a]	Period	% change
1963	1,310	1963-68	27.8%
1968	1,674	1968-73	21.9%
1973	2,041	1973-78	16.4%
1978	2,376	1978-83	29.9%
1983	3,087	1983-88	28.7%
1988	3,974		
		1963-88	203.4%
		1973-88	94.7%

Note: [a] Based on assumed 54% of all coated paper shipments.

Source: API 1989 Statistics of Paper, Paperboard, & Wood Pulp.

Table 2.17
Shipments of Special Industrial Paper Grades, 1963-1988
Selected Years
('000 Tons)

Year	Shipments	Period	% change
1963	314.4	1963-68	41.8%
1968	445.8	1968-73	45.8%
1973	650.1	1973-78	-15.2%
1978	551.0	1978-83	91.1%
1983	1,052.7	1983-88	12.6%
1988	1,185.8		
		1963-88	277.2%
		1973-88	82.4%

Source: API 1989 Statistics of Paper, Paperboard, & Wood Pulp.

Table 2.18
Shipments of Tissue Grades 1963-1988
Selected Years
('000 Tons)

Grade	1963	% change 1963-68	1968	% change 1968-73	1973	% change 1973-78	1978	% change 1978-83	1983	% change 1983-88	1988	% change 1963-88	% change 1973-88
Tissue papers	2,576.4	34.1%	3,455.9	16.9%	4,038.8	4.4%	4,214.8	13.6%	4,788.6	14.4%	5,476.1	112.5%	35.6%
Sanitary tissue stock	2,340.4	37.5%	3,217.2	17.2%	3,771.8	6.5%	4,017.4	14.8%	4,611.2	14.6%	5,282.4	125.7%	40.0%
Toilet tissue	1,054.6	20.7%	1,273.1	13.1%	1,440.5	14.1%	1,643.2	11.7%	1,835.2	10.7%	2,032.3	92.7%	41.1%
Facial tissue stock	278.4	25.6%	349.8	3.4%	361.8	-9.1%	329.0	18.3%	389.3	-9.7%	351.4	26.2%	-2.9%
Napkin stock	261.3	43.4%	374.7	19.5%	447.7	10.1%	493.1	8.0%	532.6	30.9%	697.4	166.9%	55.8%
Towelling	662.9	62.6%	1,077.7	18.4%	1,276.4	3.2%	1,317.6	19.7%	1,577.2	18.1%	1,863.3	181.1%	46.0%
Wiper stock	33.1	52.0%	50.3	21.9%	61.3	-26.9%	44.8	-	NA	-	NA	-	-
Other sanitary tissue	50.0	83.0%	91.5	101.2%	184.1	3.0%	189.6	46.0%	276.9	22.1%	338.0	576.0%	83.6%
All other tissues	236.0	1.1%	238.7	11.9%	267.0	-26.1%	197.4	-10.1%	177.4	9.2%	193.7	-17.9%	-27.5%

Source: 1989 API Statistics of Paper, Paperboard, & Wood Pulp.

- Toilet tissue (37% of all tissue);
- Toweling, including roll and fan-folded paper towels for consumer, commercial, and industrial uses (34%);
- Napkin stock, also for consumer and commercial use (13%);
- Facial tissue (6%).

As seen in Table 2.18, tissue shipments have increased over the period 1973-88 from 4.0 million to 5.5 million tons. This represents an increase of 35.6 percent. Toilet tissue, toweling, and napkin stock have increased by somewhat higher percentages, while remaining grades, particularly facial and non-sanitary grades, have experienced declines.

In contrast to most papers, sanitary paper products are sold by highly sophisticated and aggressive advertising programs. In 1980, sanitary paper products accounted for over 70 percent of all traceable media expenditures of the entire paper industry (Kline & Co., 1980). These highly developed media techniques contribute to growth in demand by emphasizing the convenience of products inexpensive enough to discard after one use. In addition, tissue products are continually improved, developing more expensive grades and therefore higher sales dollar volumes. Possibly countering this growth is the market saturation of such products as toilet tissue and an increasing environmental awareness that may lead the consumer to switch from paper to cloth for some products such as towels.

2.5.6 Bureau of the Census Data

Further data on the percent of paper and board grades that are bleached was obtained from a special tabulation by the U.S. Bureau of the Census from its Pulp, Paper, and Board Survey (MA26A). The survey covers all pulp and paper mills in the U.S., and is designed to collect information on aggregate U.S. shipments of pulp, paper, and paperboard products. The survey data indicates the minimum quantity and percentage of paper and board grades which are produced in an unbleached form.

According to the survey, a minimum of about 44% of all paper and board is unbleached. Specific grades with a relatively high minimum percentage of unbleached shipments include: construction paper and board (minimum of 97% unbleached), recycled paperboard (89%), solid wood pulp furnish paperboard (68%), packaging and industrial converting paper (44%), tissue paper excluding sanitary and thin (28%), newsprint (24%), uncoated groundwood paper (8%), and sanitary tissue (8%). This information is consistent with the estimates of bleached virgin pulp content by product that was presented in Table 2.10. For more information regarding the Bureau of the Census survey, see Appendix 2.D.

2.6 Conclusions

The product segments of greatest interest for this analysis are those that consume the most chlorine-bleached pulp. Both virgin paper and recycled fibers can be bleached. To

identify the products that compel the initial use of bleached fibers, this analysis focuses on products which use bleached virgin pulp rather than bleached recycled pulp.

Estimates of chlorine-bleached virgin pulp usage by product type are, however, not readily available. In the absence of this data, this report identifies product segments of interest based on usage of bleached virgin kraft pulp; that is, the sole pulping method considered is the kraft process and the bleaching method is not restricted to chlorine. Since kraft pulping is the predominant pulping process and chlorine bleaching is the major bleaching method used for kraft pulp, the results of the analysis should be representative of all chlorine-bleached virgin pulp. The estimates of bleached kraft pulp usage, as calculated from Table 2.10, are shown in Table 2.19.

As can be seen from Table 2.19, three market segments use over 85% percent of bleached virgin kraft pulp. These are: (1) printing/writing papers (58% of total bleached virgin kraft pulp), (2) solid bleached paperboard (16%), and (3) tissue (13%). Figure 2.5 displays these percentages graphically. Within printing and writing papers, free sheets use 45 percent of total kraft bleached pulp - 35 percent is used in uncoated free sheets and 10 percent in coated free sheets. Within solid bleached paperboard, boxboard uses 12 percent of total kraft bleached pulp.

The percentages of bleached virgin pulp in a product will not, however, exactly reflect the percentage of the pulp that is bleached with chlorine. It is likely, for example, that mechanical pulps will not be bleached with a chlorine process; sodium hydrosulfite and hydrogen peroxide are generally used for bleaching lignin-rich mechanical pulps (Office of Technology Assessment, 1989). Therefore, products made from bleached mechanical pulp are likely to have used less chlorine than products made from bleached chemical pulp.

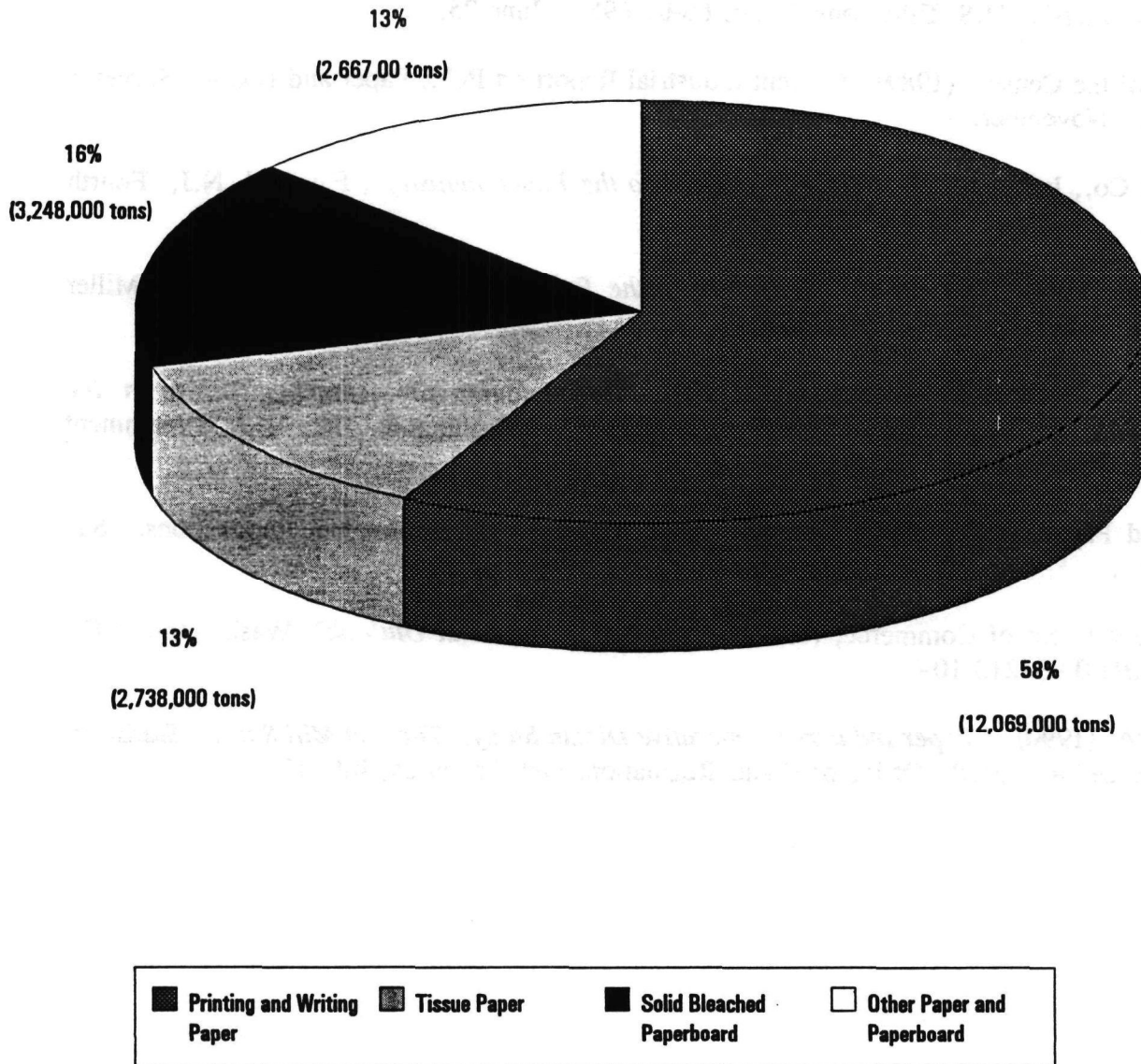
Both bleached free sheets and bleached boxboard are likely to have been bleached with chlorine since they are manufactured largely from chemical pulp. By definition, free sheets contain less than 10% mechanical pulp (though, with recent advancements, mechanical pulp content may be somewhat higher). Kraft pulp is also the major fiber used in producing bleached boxboard for the packaging industry (Office of Technology Assessment, 1989). Tissue products are also manufactured mostly from bleached kraft and sulfite pulps, though all pulp types are used to some extent. Therefore, the bleaching agent for all three types of paper is likely to be chlorine. The determination of precise quantities of chlorine-bleached pulp used in these products requires research beyond the scope of this project. Given the available information, printing/writing paper (with particular attention to free sheets), tissue, and boxboard will be the focus of the remainder of the analysis.

Table 2.19
Bleached Virgin Pulp Content by Product Type

	Use of Bleached Virgin Pulp ('000 tons)	Percent of Total Bleached Kraft Virgin Pulp Use
PAPER	17474	84%
<u>Newsprint</u>	1196	6%
<u>Printing/Writing Paper</u>	12069	58%
uncoated groundwood	292	1%
coated groundwood	1279	6%
coated free sheet	2110	10%
uncoated free sheet	7217	35%
thin papers	195	1%
cotton fiber	45	0%
bleached bristols	931	4%
<u>Packaging/Industrial Papers</u>	1471	7%
unbleached kraft	0	0%
bleached packaging	398	2%
wrapping	21	0%
bag and sack	224	1%
shipping sack	95	0%
other converting	59	0%
specialty packaging	510	2%
special industrial papers	563	3%
<u>Tissue</u>	2738	13%
toilet	1016	5%
facial	176	1%
napkins	349	2%
toweling	932	4%
other sanitary tissue	192	1%
all other tissue	97	0%
PAPERBOARD	3248	16%
<u>Unbleached kraft</u>	0	0%
<u>Solid bleached</u>	3248	16%
linerboard	138	1%
boxboard (folding carton and milk carton & food service)	2426	12%
other	184	1%
exports	452	2%
<u>Semichemical paperboard</u>	0	0%
<u>Recycled paperboard</u>	0	0%
TOTAL	20722	100%
Source: See Table 2.10.		

Figure 2.5

Bleached Kraft Pulp Consumption by Type of Product
(Percentage of Total U.S. Bleached Kraft Pulp Consumption by Weight, 1988)



Source: American Paper Institute. 1989 Statistics of Paper, Paper Board, and Wood Pulp. Arthur D. Little, Inc., Exposure and Risk Assessment of Dioxin in Bleached Kraft Paper Products. U.S. EPA Contract No. 68-01-6951. June 25, 1987 Eastern Research Group, Inc. Estimates.

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CHAPTER 3: CHARACTERISTICS OF BLEACHED PAPER

There are many steps in the process of converting wood and other cellulose-containing materials into paper and paperboard products, and each step has some influence on both the subsequent steps and the final product. The basic steps include pulping, bleaching (if desired), and papermaking. This chapter discusses pulping and bleaching and describes the technical requirements that influence whether pulp is bleached, and the specific types of bleaching that would be appropriate.¹

3.1 Factors Affecting Paper Attributes

The characteristics of paper and paperboard (such as weight, color, strength, ability to absorb or resist water, surface texture, and permanency) depend on a myriad of factors including:

- the source of the cellulose (hardwood or softwood, virgin or recycled fibers, and wood or non-wood fibers such as cotton or grasses),
- the type of pulping and bleaching processes and the chemicals used in the pulping/bleaching processes and/or added to the pulp,
- the type of paper-making process and the substances added during this process.

3.1.1 Source of Cellulose

The papermaking process starts with the separation of the cellulosic fibers (usually wood fibers) from which paper is formed. The source of cellulose has more influence on the strength of the paper than on the extent of bleaching and brightening; softwoods tend to have longer fibers than hardwoods and thus produce a stronger paper. The amount and type of bleaching/brightening undertaken is more a function of the pulping process than of the type of wood.

In many cases, secondary or recycled fibers that have previously been bleached need little or no bleaching. It may be necessary, however, to deink the pulp. High-quality recycled office or white paper needs little deinking and recycled pre-consumer paper may need no deinking. There is some question, however, as to the number of times fiber can be recycled, as continued repulping will result in increasingly shorter fibers and therefore a reduction in the fiber strength.

¹Appendix 3.A contains further information on pulping.

According to current estimates, a paper fiber can be reused six to eight times. For many types of uses, therefore, a mixture of secondary and virgin fibers is used, and the virgin fiber may be bleached even when the secondary fiber is not. To the extent that the production of high-quality white recycled papers depends on the use of bleached office papers as the source of secondary fibers, recycling may reduce but not eliminate bleaching.

3.1.2 Pulping Processes and Bleaching/Brightening Pulps

The types of chemicals used to bleach, and the extent of the bleaching, varies with the type of pulping process and the intended use of the pulp. Table 3.1. lists the major wood pulping techniques and typical end-product uses for the pulp.

The two major pulping processes are chemical pulping and mechanical pulping. Mechanical pulping uses abrasion of the wood in a grinder or refiner to physically tear the fibers apart. Mechanical processes tend to produce high yields but pulps of low strength (the fibers are chopped indiscriminately). The chemical pulping process involves the use of chemicals, heat, and pressure in a digester to dissolve the lignin (i.e., delignify). Lignin is the noncarbohydrate portion of the plant cell wall and is responsible for cementing and strengthening the wood fibers and the coloration of the wood. Removal and bleaching of the lignin is necessary to allow flexibility of the fibers and reduce discoloration of the paper with age.

Chemical processes tend to produce pulps of high strength because the fibers are chemically separated, not ground. However, chemical pulping processes have low yields due to removal of the lignin. The two main types of chemical pulping processes are the sulfate or kraft process and the sulfite process. These differ in that the kraft process produces a very strong brown pulp, while the sulfite process produces a less strong but lighter colored pulp.

Bleaching Related to Types of Pulping

Most of the pulp and paper industry's chlorinated organic contaminants, including dioxin, originate in the bleaching processes. A wide range of bleaching and caustic washing sequences may be used to bleach and brighten pulp. The choice of which bleaching agents, and in what sequence, is generally determined by the pulp characteristics desired, such as brightness and strength, balanced against capital and operating costs. Molecular chlorine has become the preferred bleaching agent because of its relatively low cost and high effectiveness.

Bleaching is used to purify and whiten pulp by chemically altering the coloring matter or by removing the lignin. The less lignin retained, the brighter the paper and the longer the paper will last without yellowing and becoming brittle. The whiteness of pulps is generally measured in terms of the amount of a nearly monochromatic light it reflects; the higher the number, the more light reflected. Since one of the most commonly used meters for measuring brightness is made by General Electric, one common brightness measure is referred to as the GE number. Unbleached pulps generally exhibit the following GE brightness levels:

Table 3.1
Major Wood Pulping Technologies

Pulp Grades	Wood Type	End-Use Product
Chemical Pulps		
Sulfite Pulp	Softwoods and Hardwoods	Fine and Printing Papers
Kraft Sulfate Pulp	Softwoods and Hardwoods	<i>Bleached</i> - Printing and Writing Papers, Paperboard <i>Unbleached</i> - Heavy Packaging papers, Paperboard
Dissolving Pulp	Softwoods and Hardwoods	Viscose Rayon, Cellophane, Acetate Fibers, Film
Semichemical Pulps		
Cold-Caustic Process	Softwoods and Hardwoods	Newsprint and Groundwood Printing Papers
Neutral Sulfite Process	Hardwoods	Newsprint and Groundwood Printing Papers
Mechanical Pulps		
Stone Groundwood	Softwoods	Corrugating medium
Refiner Mechanical Pulp	Softwoods	Newsprint and Groundwood Printing Papers
Thermomechanical Pulp	Softwoods	Newsprint and Groundwood Printing Papers
Source:	<i>Technologies for Reducing Dioxin in the Manufacture of Bleached Wood Pulp: Background Paper</i> , Congress of the United States, office of Technology Assessment, May 1989, p.18.	

Sulfite	up to 65
Groundwood	40 to 60
Kraft, Semichemical	25 to 35

It is interesting to note that the two chemical pulping processes produce the pulps with the highest and the lowest brightness levels. Sulfite pulps are used predominately in fine writing and printing papers, so the initial high brightness levels are very desirable. The sulfite process is not more widely used, however, because it is limited in terms of the types of wood that can be used and because there are greater environmental controls on the by-products of this process than on kraft processes. In particular, the sulfite process produces significant amount of sulphur dioxide. Some kraft pulp is used for printing and writing papers, and the amount has grown as kraft bleaching processes have advanced.

There are two basic methods to increase the brightness of pulp. The first method is to use bleaching agents that destroy at least a portion of the colored compounds without significantly reacting with the lignin. This method is used to brighten pulps with high lignin content, such as groundwood and semichemical. In these cases, significant delignification is not desirable since high yields are desired from these pulping methods. However, brightness values above GE 70 are difficult to achieve without delignification. Substitution of bleached mechanical pulps for bleached chemical pulps on a large scale, therefore, is not likely for uses which require a high brightness level. In the past, much of the mechanical pulp was not bleached, but the bleaching of groundwood has increased and improved technology now enables bleached groundwood pulp to be used for printing papers, tissue and toweling. Chemicals used to destroy coloring impurities include: sodium bisulfite, calcium or sodium hypochlorite, and hydrogen or sodium peroxide.

The second method includes complete or near-complete removal of the lignin remaining after chemical pulping, followed by further bleaching of the pulp to a desired degree of brightness. Conventional bleaching of kraft and sulfite pulps involves three principal types of reactions:

- Chlorination under acid conditions (pH 2-4),
- Alkaline extraction, to remove the dissolved lignin (pH 10-11.5),
- Further brightening using hypochlorites, chlorine dioxide, and/or hydrogen peroxide.

Brightness values of 80 and higher may be attained without adverse impacts on pulp strength using hypochlorites for final bleaching. Selective use of chlorine dioxide in place of hypochlorites permits brightness of 90 and above.

Bleaching Impacts on the Quality of Pulp

While high brightness is a valued characteristic of bleached pulp, strength is another important papermaking characteristic that can be adversely affected by the amount and type of bleaching. Additional papermaking characteristics that can be affected by bleaching are: density, viscosity, and freeness. Density is a measure of the weight per given volume, viscosity measures the degree to which a solution of the pulp resists flowing, and freeness measures the rate at which water drains from the pulp in the papermaking process.

A critical determinant in choosing a bleaching chemical is the "selectivity" of the agent. Selectivity refers to the capacity of the chemical to attack lignin while doing minimal damage to the cellulose fibers. A selective chemical will increase brightness while not reducing the strength of the pulp. Unbleached kraft pulp (brown stock) contains relatively high levels of lignin in the initial stages of bleaching, and therefore less selective chemicals (e.g. oxygen and chlorine) can be used at this stage of the bleach cycle. As delignification occurs, however, a greater proportion of the non-selective chemical is available to react with the cellulose, adversely affecting the strength of the pulp.

Since the 1930s, molecular chlorine has been the predominant chemical used for the delignification of pulp. It is both effective and economical to use. If used improperly, however, it can result in loss of pulp strength. Hypochlorite is another bleaching chemical that is easy to make and use but which can result in loss of pulp strength if used improperly. Oxygen delignification requires expensive equipment and also can result in loss of pulp strength. On the other hand, chlorine dioxide and hydrogen peroxide are highly selective; they react rapidly with lignin but affect cellulose very little, thus affecting pulp strength minimally. Both chemicals, however, are expensive, and chlorine dioxide must be made at the mill site (Clement Associates, 1989).

Bleaching Sequence

The impact of these chemicals on pulp strength and brightness varies, depending on when in the bleaching sequence and with which other chemicals they are used. There are two phases to bleaching chemical pulp: delignification and extraction, which are carried out in alternating acid and alkaline stages. Between adding the acidic bleaching chemicals, which continue the delignification process begun in the digester, alkaline chemicals are added to extract the dissolved lignin from the fibers. The first delignification and extraction stages of a normal bleach sequence constitute pre-bleaching and all subsequent states are referred to as the final bleach (U.S. EPA, 1990).

The standard abbreviations used to describe the different bleaching chemicals and types of types of bleaching stages in a bleach plant are:

<u>Bleach Stage</u>	<u>Description</u>
O	Oxygen delignification. Oxygen is applied in an alkaline environment under pressure prior to chlorine bleaching for partial delignification. Linked with the pulping chemical recovery system.
C	Chlorine or C-Stage. Chlorine Dioxide (D) may be added in the C-Stage.
E	Caustic extraction or E-Stage. Oxygen (O), Sodium Hypochlorite (H), or Hydrogen Peroxide (P) may also be used in the E-Stage.
H	Hypochlorite or H-Stage.
D	Chlorine Dioxide or D-Stage.
P	Hydrogen Peroxide or P-Stage
Z	Ozone or Z-Stage.

Conventional bleaching sequences are typically **CEHED** or **CEDED**, where molecular chlorine is applied in the first bleaching stage, followed by caustic extraction, hypochlorite or chlorine dioxide bleaching, a second extraction stage, and a final bleaching stage. The more recent trend has been toward short sequence bleaching with chlorine dioxide substitution for some portion of the chlorine in the C-Stage, and use of oxygen in the E-Stage, or **(CD)(EO)D**. (When more than one chemical is applied in one bleaching stage, the chemical with the highest usage is listed first.) A mill that uses oxygen delignification prior to bleaching would be characterized as **O(CD)(EO)D** or **O(DC)(EO)D**, depending upon the degree of chlorine dioxide substitution (Amendola, 1990b).

Prebleach - Delignification

The first bleaching stage(s) are designed to remove most of the lignin (delignification) and involves little improvement in the brightness of the pulp. Removing the bulk of the lignin minimizes the volume of more expensive bleaching chemicals (e.g. chlorine dioxide, hypochlorite, and hydrogen peroxide) needed in the later stages. Molecular chlorine has been the preferred chemical for the prebleaching process. Chlorine reacts selectively with lignin, under normal bleaching conditions does little harm to cellulose fibers, and is relatively inexpensive.

There is a trend toward modifying the first chlorination stage by including other bleaching agents (e.g. chlorine dioxide either mixed with, or in sequence with, the chlorine). Inclusion of these chemicals can reduce cellulose degradation, improve pulp strength, and reduce environmental releases. While chlorine dioxide can be used to completely replace molecular chlorine in the prebleaching stage, it has two significant drawbacks. First, it is more expensive

than molecular chlorine. Second, it can not achieve pulp brightness equivalent to that produced by molecular chlorine.

An additional modification is to use oxygen as a delignifier prior to the chlorination stage. Oxygen is an effective delignifier and reduces the amount of bleaching chemicals needed in subsequent stages. Another variant is to use hydrogen peroxide with oxygen. Peroxide acts as a good delignifier and significantly reduces the amounts of chlorine, chlorine dioxide and/or hydrogen peroxide needed in subsequent stages.

Extractive Stages

Between each bleaching stage the pulp is washed with an alkali extraction solution to remove the dissolved lignin. Oxygen gas added to the sodium hydroxide in the extraction stage decreases the kappa number (amount of lignin), conserves chemicals in subsequent bleaching stages (reducing the number of bleaching stages in some cases), and reduces the loss in pulp strength.

Adding peroxide to the extraction in addition to oxygen further increases the lignin removal: using oxygen alone in the extraction stage results in 10 to 15 percent delignification, while adding peroxide (0.3-0.4%) to this stage results in 30 to 35 percent delignification. Peroxide is most effective when used with ozone, oxygen and/or chlorine.

Final Bleach Delignification (or Brightening Stages)

Chlorine dioxide is very selective and produces high brightness pulp. Chlorine dioxide is generated as a gas at the mill and dissolved in cold water. Because of its high cost, it is commonly used at or near the end of the bleaching sequences, in addition to its use in conjunction with chlorine in the first stage.

Peroxide is a very effective cellulose-preserving bleaching agent and is well suited for improving the brightness of highly lignified pulps, such as mechanical groundwood and chemi-mechanical pulps, without significantly reducing yields. It is used in the intermediate stages of the bleaching sequence as a replacement for hypochlorite or chlorine dioxide, and it is frequently used as the last stage in the bleaching sequence where it can add a few points of brightness to the pulp and improve its brightness stability. Peroxide alone is a relatively ineffective means for bleaching kraft pulp. However, when used in sequences with chlorine-based bleaching agents, peroxide is an efficient delignifier and brightener.

Hypochlorite was used for bleaching before the development of chlorine bleaching technologies, and about 40 percent of North American mills still use at least one hypochlorite stage in their bleach sequence. It is most appropriate for sulfite mills; kraft pulps are more difficult to bleach and require a chlorine and alkaline extraction stage to be added to the sequence. Until chlorine dioxide and peroxide processes became available in the 1940s, kraft pulps of 85 brightness were the brightest that could be produced with hypochlorite bleaching

while maintaining acceptable pulp strength. These pulps, however, had poor brightness stability. One possibly significant drawback to the use of hypochlorite is its apparent link to the production of chloroform. The specific conditions and reactions contributing to the production of chloroform are not well known, however, and more research is needed to establish causation.

Ozone is a very powerful bleaching and oxidizing agent. The decomposition of ozone into oxygen after bleaching produces neither a residue nor undesirable inorganic by-products. In a bleaching sequence with hydrogen peroxide, ozone can produce high-brightness pulps. In conjunction with preliminary oxygen delignification, ozone may reduce the amount of chlorine and hypochlorite used in the bleaching sequence. Ozone bleaching is particularly well suited to bleaching sulfite pulps because of their low residual lignin content. High-brightness, high-quality, hardwood kraft pulps can be produced by using ozone in the first stage of the bleaching sequence. The first commercial ozone-based pulp bleaching process has been announced by Union Camp for its Isle of Wight, Virginia paper plant. According to company officials, this unit will completely eliminate the use of molecular chlorine. With the Union Camp **OZED** sequence, ozone (**Z**) will be used in place of chlorine and chlorine dioxide in the first bleaching stage to bleach southern pine. The company plans to use chlorine dioxide for final bleaching. The line is scheduled to be placed in operation in 1992. In addition, Union Camp expects to license the process to other paper companies on a royalty basis and has received inquiries from several groups (Chemicalweek, 9/5/90).

Distinctions Between Using Reduced Levels of Chlorine, Molecular Chlorine-free (MCF) Bleaching, and Totally Chlorine-Free (TCF) Bleaching

As indicated by data in the Section 308 National Census, many mills are reducing their use of chlorine through increased substitution of chlorine dioxide, oxygen delignification, or other methods (see Table 1 in the Executive Summary). For example, adding an oxygen delignification stage (e.g., an O-C-E-D sequence) could reduce the quantity of chlorine needed in comparison to a traditional chlorine sequence. The feasibility of reducing levels of chlorine often depends on the fiber source, pulping process and pre-bleaching pulp treatment. For example, many secondary fiber mills conduct mild bleaching using chlorine or hypochlorites at rates substantially less than necessary for bleaching virgin kraft pulps. Also, the amount of chlorine used to bleach sulfite pulps is often less than the amount used to bleach kraft pulps. Finally, there are differences in chlorine application rates for bleaching kraft hardwood vs. kraft softwood pulps, and for bleaching oxygen delignified kraft pulps vs. conventional kraft pulps. Hence, it is important to consider relative use of chlorine in the context of the fiber source, pulping process and pulp treatment prior to bleaching with chlorine.

Buckeye Cellulose in Oglethorpe, Georgia, is an example of one mill implementing complete substitution of chlorine with chlorine dioxide. The resulting pulp, therefore, is MCF. An example of an MCF bleach sequence is OD(EO)D, using oxygen delignification to minimize chlorine dioxide consumption. Note, however, that while molecular chlorine is not directly

applied, a chlorine compound in the form of chlorine dioxide (D) is used in the first bleaching stage as well as in a subsequent bleaching stage. Therefore the pulp is MCF, not TCF.²

A TCF bleaching sequence would most likely require some form of extended delignification in the pulping process followed by oxygen delignification prior to bleaching. Many, if not most, U.S. mills would require major pulping and bleach plant modifications to accommodate such changes on a retrofit basis. Currently, no U.S. mills are known to be bleaching TCF kraft pulps. There were no such mills when the *104 Mill Study* was conducted in 1988. Recently, the Louisiana-Pacific mill in Samoa, California adopted plans to begin production of TCF kraft pulp as part of a settlement agreement with the EPA, the Department of Justice, the State of California, and the Surfriders Foundation.

3.1.3 Papermaking

Bleached and unbleached pulps are further processed to obtain desired qualities in finished paper, such as proper surface, opacity, strength, and feel. Pulp is prepared for formation into paper by mechanical treatments, called beating and refining. Generally, beating and refining make the finished paper stronger, more uniform, more dense, more opaque, and less porous.

About 70 percent of the paper produced is sized to resist penetration of liquids, either internally as the paper is being made on the paper machine, or externally after the paper sheet is formed. Rosin, rosin size, emulsified waxes, fortified sizes, bituminous emulsions, latex, silicones are examples of paper sizes used. They are usually applied with various precipitants including alum, sodium aluminate and others in specific proportions to impart the desired degree of sizing.

Fillers are added to most papers to improve texture, print quality, opacity, brightness and to affect certain physical properties such as pore size (for filterability), porosity, burning rate (for cigarette papers), and formability. Fillers can also have adverse effects on finished paper quality including increase in softness, loss of strength, reduction in pick resistance (a printing quality), or two-sidedness, which is a difference in paper qualities on opposite sides of a sheet. Fillers commonly used include clays, silicas, talc, and certain inorganic chemicals - calcium sulfate, barium sulfate, zinc sulfide and titanium dioxide.

Many papers are colored through the addition of inorganic and organic dyes and pigments. Shade control of the paper product can be affected of addition of dyes and pigments, pH control, mechanical adjustments in beating and refining, the use of fillers, the type of pulp used, and other mill procedures. Dyes and pigments are added before the paper is formed for most products.

²Depending upon the method of manufacture of chlorine dioxide, some molecular chlorine may also be present.

For many types of paper, the grade of the paper depends in part on its brightness level. For example, according to standards published in Walden's Handbook, premium bond paper has brightness levels between 90 and 92, while number 5 bond paper has brightness levels from 79 to 82. As shown in Table 3.2, the brightness level of paper varies across grades. Generally, groundwood papers have lower brightness levels than free sheets and are not considered to be high quality papers. It is the brightness standards established for the highest grades that chlorine-free paper may be unable to meet.

3.2 Summary

As described above, several production processes impact the performance qualities of paper. Table 3.3 summarizes the manufacturing processes that correspond to specified paper performance qualities. The manufacturing processes listed in the table are those which generally correspond to listed paper characteristics; however, the most effective process will vary with the specific end product. Further, the listed individual manufacturing processes may not be optimal when integrated.

From the table it can be seen that to maximize paper strength a softwood furnish is desirable as is a kraft bleaching process. In particular, it is interesting to note that while chlorine bleaching improves permanence and brightness, it is detrimental to paper strength. Also, bleaching, whether chlorine based or not, adds to the production costs of the paper.

Building on Table 3.3, Table 3.4 presents performance requirements for major paper products as well as the preferred production processes given these requirements. While the preferred processes are not always those actually used in the production of these products, they are most likely to be used based on the product performance requirements.

Since there is no single relationship between the use of chlorine and the type of paper products produced, there are no simple responses to the question of whether or not chlorine is needed in making paper. From a technical perspective, it is possible to make any type of paper, broadly enough described, without molecular chlorine. That is, it is possible to produce some form of tissue, printing/writing paper, boxboard, etc. without chlorine. However, whether the products produced without chlorine would meet the quality demanded by the market at an acceptable price is less clear. To further complicate the issue, the use of chlorine by the paper industry is in a very fluid situation at the moment. As the concern over the generation of dioxin has increased, new technologies that reduce the use of chlorine are being developed. The current situation can be described in terms of the major findings of this chapter.

- The extent of bleaching, and the bleaching chemicals used, are a function of the type of pulping process and the intended end-use of the pulp. To a lesser degree, bleaching depends on the type of wood used.

Table 3.2
Paper Brightness Levels

Grade Levels	Brightness (GE)	Opacity
White Business Papers (All 20#)		
Bond		
Premium	90-92	84
Number 5	79-82	88
Mimeo		
Number 1	85-89	88
Number 5	79-81	89
Duplicator		
Number 1	85-89	88
Number 5	79-81	86
Groundwood	75-78	91
Xerographic		
Number 1	89-90	88-89
Number 4	83-84	91-92
Roll-Copy		
Number 1	89-90	88-89
Number 4	83-84	91-92
White, Coated Web Offset Papers (All 80#)		
Glossy Finish		
Premium Double	93	96
No. 4 Single	73-78	95
Dull Finish		
Premium Double	93	96
No. 4 Single	73-78	95
Matte Finish		
Premium	93	96
No. 5	72-below	94

**Table 3.2, cont.
Paper Brightness Levels**

Grade Levels	Brightness (GE)	Opacity
White, Coated Offset Paper		
Glossy Finish (70#) Premium Double No. 5 Single	86-91 72-lower	95 92
Dull Finish (70#) Premium Double No. 5 Single	86-91 72-lower	90
Matte Finish (80#) Premium No. 5	93-94 72-below	96 94
White, Uncoated Offset Paper (60#)		
Premium No. 2-Opaque No. 1-Offset No. 5-Offset Groundwood	95-97 87-89 85-87 80-82 69-72	94 94 93 92 96
White, Coated Letterpress Paper		
Glossy Finish No. 1 (70#) No. 4 (60#) No. 5 (40#) Groundwood No. 1 (40#) Groundwood No. 3 (40#)	85 71 69-70 72-74 64-67	95 95 90 88 86
White, Coated Gravure Paper	70#	80#
No. 5	70-71	95
Source: <i>Walden's Handbook</i> , Second Edition; Walden-Mott Corporation, Oradell, New Jersey; Copyright, 1981.		

Table 3.3
Relationship of Selected Pulp and Paper Performance Qualities to Manufacturing Processes

Quality Performance Requirements	Preferred Furnish ¹	Preferred Pulping Process	Preferred Bleaching Process	Preferred Coatings & Sizings	Preferred Beating & Refining
MECHANICAL CHARACTERISTICS					
Strength Tensile Bursting Tearing Resistance Folding Endurance	Softwood	Chemical Kraft	Unbleached	West str. Resins, rosin size, Starch	Increased Increased Decreased Increased
APPEARANCE PROPERTIES					
Brightness	HW/SW ¹	Chemical Sulfite	Chlorine-based CEHED (CD)(EO)D O(CD)(ED)D O(DC)(EOP)D Others	TiO ₂ Dyes	No effect
Opacity	HW/SW	Mechanical NSSC ² Chemical Kraft Sulfite	See brightness, dependent upon products	Fillers, Dyes	Decreased
Gloss	HW/SW	See opacity, dependent upon product	See brightness, dependent upon product	Fillers Coatings	No effect
BARRIER AND RESISTANCE PROPERTIES					
Moisture Resistance	HW/SW	Chemical Kraft Sulfite	No effect	Internal sizing (rosin size-alum, wax emulsions, synthetics) External sizing (starches, gums, glues, polyvinyl alcohol) Polyethylene, Polyvinylidene	No effect

1. HW/SW indicates either hardwood or softwood.

2. Neutral Sulfite Semi-Chemical.

**Table 3.3, cont.
Relationship of Selected Pulp and Paper Performance Qualities to Manufacturing Processes**

Quality Performance Requirements	Preferred Furnish ¹	Preferred Pulping Process	Preferred Bleaching Process	Preferred Coatings & Sizings	Preferred Beating & Refining
Permanence	HW/SW	Chemical Kraft	Chlorine-based, See above Sulfite	Alkaline or neutral sizes and fillers	Decreased
Absorbency	HW/SW	Chemical Kraft	No effect	Wetting agents	Decreased
Economy	Sec. Fiber: high grade deinking, boxboard	Hydro-pulping	Single stage (Ca. hypochl.) Unbleached	None	None
	Virgin Fiber: SW	Mechanical groundwood	Unbleached	None	None
Sources: (1) Smook, G.A., <i>Handbook for Pulp and Paper Technologists</i> , Joint Textbook Committee of the Paper Industry, TAPPI, Technology Park/Atlanta, Atlanta, Georgia, 1982. (2) Scott, S.E. and Trosset, S., <i>Properties of Paper: An Introduction</i> , TAPPI, Technology Park/Atlanta, Atlanta, Georgia, 1989 (ISBN 0-89852-052-5) (3) <i>Walden's Paper Catalog</i> , Walden-Mott Corporation, Oradell, New Jersey, Spring 1990. (4) <i>Walden's Handbook</i> , Walden-Mott Corporation, Oradell, New Jersey, Second Edition, 1981. (5) <i>Tappi Proceedings - 1989 Papermakers Conference</i> , TAPPI Press, Technology Park/Atlanta, Atlanta, Georgia, 1989.					

1. HW indicates either hardwood or softwood.
 2. Sulfite Semi-Chemical.

Table 3.4
Performance Requirements and Preferred Production Methods by Major Grade

Product	Performance Requirements	Preferred Furnish ¹	Preferred Pulping Process	Preferred Bleaching Process	Preferred Coatings & Sizings
PRINTING GRADES					
Newsprint	Runnability, Printability, Appearance Brightness (68-72) Cleanliness Opacity Moderate Strength	HW/SW	Mechanical & Chemical Sulfite Kraft SW	None None Semi-Bleached	Variable
Publication	See Newsprint Brightness (72-88)	HW/SW	Mechanical & Chemical	None or Semi-BI. Semi-Bleach to Fully Bleached	TiO ₂ , clay, synthetics
Bond, Ledger	See Newsprint Brightness (79-92)	HW/SW, Rag	Chemical Kraft Sulfite	Fully Bleached	Variable
Stationery	Appearance Brightness Opacity Strength Stiffness Erasability Ink Resistance Surface Texture Permanence	HW/SW Rag	Chemical Sulfite Kraft	Fully Bleached	Internal Size Top size Fillers

1. HW/SW indicates either Hardwood or Softwood.

Table 3.4, cont.
Performance Requirements and Preferred Production Methods by Major Grade

Product	Performance Requirements	Preferred Furnish ¹	Preferred Pulping Process	Preferred Bleaching Process	Preferred Coatings & Sizings
Bleached Bags, Wrapping, Food Packaging	Strength Stiffness Brightness Cleanliness	HW/SW	Kraft	Fully Bleached	Variable
Greaseproof, Glassine	Grease Resistance Water Resistance	HW/SW	Sulfite	Unbleached	Variable
PAPERBOARD					
Corrugating Medium	Stiffness Economy	Hardwood	Semi-chemical	Unbleached	Variable
Linerboard	High Strength Appearance Printability (one surface)	Southern Pine	Kraft	Unbleached	Variable, Wet Strength
Boxboard	See Linerboard	Southern Pine	Kraft	Unbleached to Fully Bleached	Variable, Wet Strength

1. HW/SW indicates either Hardwood or Softwood.

Table 3.4, cont.
Performance Requirements and Preferred Production Methods by Major Grade

Product	Performance Requirements	Preferred Furnish ¹	Preferred Pulping Process	Preferred Bleaching Process	Preferred Coatings & Sizings
Toweling	Absorbency Water-Holding Capacity Bulk Strength - Wet Formation Appearance Softness	HW/SW Sec. Fiber	Sulfite Kraft Mechanical	Unbleached to Fully Bleached	Wetting Agents
Creped Wadding	See Toweling	HW/SW Sec. Fiber	Sulfite Kraft	Unbleached to Fully Bleached	Variable, Wetting Agents
Sources: (1) Smook, G.A., <i>Handbook for Pulp and Paper Technologists</i> , Joint Textbook Committee of the Paper Industry, TAPPI, Technology Park/Atlanta, Atlanta, Georgia, 1982. (2) Scott, S.E. and Trosset, S., <i>Properties of Paper: An Introduction</i> , TAPPI, Technology Park/Atlanta, Atlanta, Georgia, 1989 (ISBN 0-89852-052-5) (3) <i>Walden's Paper Catalog</i> , Walden-Mott Corporation, Oradell, New Jersey, Spring 1990. (4) <i>Walden's Handbook</i> , Walden-Mott Corporation, Oradell, New Jersey, Second Edition, 1981. (5) <i>Tappi Proceedings - 1989 Papermakers Conference</i> , TAPPI Press, Technology Park/Atlanta, Atlanta, Georgia, 1989.					

1. HW/SW indicates either Hardwood or Softwood.

- Mechanical pulps tend to not be bleached; when bleached, chlorine is seldom used as the agent. Due to their high lignin content, which is both an advantage (high yields) and a disadvantage (low brightness, rapid yellowing, and low durability), mechanical pulps tend to be used for printing papers which do not require good quality color reproduction nor durability, such as newspapers and catalogs.
- Chemical pulping processes produce strong pulps, containing little lignin. They are often bleached; the sulfite pulps need less bleaching than the kraft pulps.
- There currently are alternatives to chlorine, but they tend to have drawbacks in terms of being:
 - more costly (e.g., chlorine dioxide and hydrogen peroxide),
 - less effective (e.g., hypochlorite), and/or
 - potential sources of other pollutants (e.g., hypochlorite may produce chloroform).
- New technologies are being developed in North America and Europe that may result in cost-effective alternatives to the use of chlorine. An example is the new Union Camp mill that will rely on the use of ozone.
- All of the non-selective bleaching elements (e.g., chlorine and oxygen) may weaken the pulp by destroying cellulose if used improperly.
- The movement towards the use of secondary fibers has reduced the amount of bleaching necessary, especially when high-quality office or white paper is recycled.
- A major industry response to the relationship between the use of chlorine and the generation of dioxin has been to substitute chlorine dioxide for chlorine. Since chlorine derivations may still produce chlorinated organic pollutants, more research is needed to determine if this shift is desirable.

- There are at least 19 processes that can reduce the use of chlorine: 12 of these technologies are available, with the remaining 7 emerging as viable technologies. Nine of the technologies are changes in pulping processes, and ten are bleaching process changes (U.S. EPA, 1990).

Chapter 3 References

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CHAPTER 4: CHARACTERIZATION OF MARKETS FOR UNBLEACHED AND ALTERNATIVELY BLEACHED PAPER PRODUCTS

This chapter characterizes the United States markets for products made from unbleached and alternatively bleached paper and paperboard. For comparison purposes, information on European markets is also presented. A variety of sources were used, including contacts with approximately 10 industry experts and environmental groups.

The chapter is arranged into six major sections. The first describes a variety of unbleached and alternatively bleached products currently available on the market, with emphasis on three product groups: printing and writing, tissue, and bleached paperboard. Together, these groups consume over 85 percent of the bleached pulp used by the paper industry. The second section characterizes both the personal and commercial consumer groups, and the third section characterizes markets for unbleached vs. alternatively bleached products. The fourth section describes the German and Swedish markets. The fifth section describes market, economic, and technological factors that may inhibit industry's adoption of alternative bleaching processes. The final section describes future trends.

4.1 Commercially Available Unbleached or Alternatively Bleached Paper Products

Table 4.1 lists examples of unbleached or alternatively bleached paper products commercially available in the United States, arranged by grade. The products were identified through a literature review and a series of telephone conversations with mill operators, paper distributors and retailers, environmental groups, and other industry experts. Further discussion of the grade categories follow the table.

The paper grades presented are those that use at least one percent of the bleached kraft pulp produced in the United States. The table lists the desirable qualities of each grade, the major uses of the paper, examples of commercially available unbleached or alternatively bleached products, major purchasers of these products, and the production processes. In addition to the type of bleaching chemicals used, the whiteness/brightness of paper can be affected by: the pulping process (e.g., sulfite pulps tend to be significantly brighter than kraft pulps), the furnish used (e.g., type of wood and/or type of recycled paper), and the coatings and fillers used to make the papers. Several of the products in Table 4.1 have adjusted these other factors in conjunction with changing and/or eliminating their bleaching agents. All of the products listed have been produced without the direct use of molecular chlorine.¹ Manufacturers of most of the alternatives listed on the table reduced or eliminated the use of

¹Although molecular chlorine was likely used to bleach paper contained in recycled paper feedstocks, mills listed as using recycled paper as feedstocks did not themselves use molecular chlorine to rebleach the recycled pulp.

Table 4.1 Paper and Paperboard Grades Containing Virgin Bleached Pulp^a and Commercially Available Unbleached or Alternatively Bleached Products

Paper Grade ^{b,1}	Percent of Total Bleached Kraft Virgin Pulp Use ^c	Desired Qualities ^b	Major Uses of Paper Grade ^b	Examples of Commercially Available Unbleached or Alternatively Bleached Products ^d	Major Purchasers ^d	Alternative Process Used ^{d,e}
High Bleached Pulp Content (75 to 90 percent of total fiber)						
<u>Coated Free Sheet</u>	10	printing quality, color, smoothness, opacity, quality surface	printing for high quality advertising, brochures, magazines, books	Mohawk Paper (Cohoes, NY)	commercial	recycled paper, either unbleached or bleached with hydrogen peroxide
<u>Uncoated Free Sheet</u>	35	printing quality, color, smoothness, opacity, quality surface, permanence	printing, writing, and related applications	Earth Care (Madison, WI) - entire catalog except one linen sheet carries recycled home and office paper produced with hydrogen peroxide, sodium hypochlorite, or unbleached	personal consumers and very small businesses	recycled paper either unbleached, or bleached with sodium hypochlorite or hydrogen peroxide
Bond and Writing	9	superior strength, performance, durability, printability, erasability, whiteness, cleanliness, freedom from fuzz, uniform finish, and good formation	legal documents, bonds, stationery, insurance policies, letterheads, business forms, data sheets, collection books; pen and ink, pencil or typewriting; now also includes office paper including copier and laser printer paper	Alte Schule (Switzerland)	personal consumers - sold through health food stores, environmental catalogs	unbleached, non-deinked 100% recycled paper
				Domtar Recycled Bond (Canada)	personal and commercial - sold retail to small, medium, and large businesses and nonprofits by Recycled Paper Company (Boston)	bleached with hydrogen peroxide, non-deinked 100% postconsumer recycled content

Table 4-1 Paper and Paperboard Grades Containing Virgin Bleached Pulp^a and Commercially Available Unbleached or Alternatively Bleached Products

Paper Grade ^{b,c}	Percent of Total Bleached Kraft Virgin Pulp Use ^a	Desired Qualities ^b	Major Uses of Paper Grade ^b	Examples of Commercially Available Unbleached or Alternatively Bleached Products ^d	Major Purchasers ^d	Alternative Process Used ^{d,e}
				Holman (Sweden)	commercial - distributed by American Paper Sales (NY, NY) mainly to environmental magazines and universities	virgin pulp bleached with hydrogen peroxide
				Cascades, Inc (Montreal, Canada) Ecofiber (sand and white)	commercial, government - distributed through Paper Choice Recycled Paper Co (Vancouver)	unbleached recycled paper
				James River (Camas, WA) Natural Copybond		unbleached virgin paper
				Rolland Inc. (St Laurent, Quebec) New Life Dual Purpose		hydrogen peroxide bleached 100% recycled content
Form Bond	7	good perforating, folding, punching, and manifolding properties	printed business forms/invoices. Most common use is carbon interleaved multi-part computer printout paper which is marginally punched, cross perforated, and fanfolded			
Carbonless	2	able to make legible reproductions via a chemical transfer of pigment due to impact from typing/writing	used primarily in producing typewritten multiple copies for business forms			

Table 4.1 Paper and Paperboard Grades Containing Virgin Bleached Pulp^a and Commercially Available Unbleached or Alternatively Bleached Products

Paper Grade ^a	Percent of Total Bleached Kraft Virgin Pulp Use ^a	Desired Qualities ^b	Major Uses of Paper Grade ^b	Examples of Commercially Available Unbleached or Alternatively Bleached Products ^d	Major Purchasers ^d	Alternative Process Used ^{d,e}
Cover and Text Paper	1	good folding qualities, printability, and durability	covers of books, magazines, catalogs, brochures, photomounts, pamphlets	Alte Schule photo albums, diaries	personal - sold through health food stores, environmental catalogs	unbleached, non-deinked 100% recycled content
				Domtar Sandpiper	commercial and personal - sold retail to small, medium, and large businesses and nonprofits by Recycled Paper Company (Boston, MA), and to consumers through catalogs and health food stores by Atlantic Recycled Paper (Baltimore, MD)	100% postconsumer non-deinked hydrogen peroxide bleached
				Simpson (US) Quest	commercial - sold retail to small, medium, and large businesses and nonprofits by Recycled Paper Company	100% postconsumer non-deinked non-chlorine bleached
				Patriot paper (Hyde Park, MA) - several lines of paper	commercial - sold retail to small, medium, and large businesses and nonprofits by Recycled Paper Company	recycled paper, 10% postconsumer non-chlorine cleaning washing bleaching system

Table 4 Paper and Paperboard Grades Containing Virgin Bleached Pulp^a and Commercially Available Unbleached or Alternatively Bleached Products

Paper Grade ^{b,c}	Percent of Total Bleached Kraft Virgin Pulp Use ^d	Desired Qualities ^b	Major Uses of Paper Grade ^b	Examples of Commercially Available Unbleached or Alternatively Bleached Products ^d	Major Purchasers ^d	Alternative Process Used ^{d,e}
				Mohawk Paper	personal consumers - sold through catalogs and health food stores by Atlantic Recycled Paper	recycled paper, either unbleached or bleached with hydrogen peroxide
Offset	9	good internal bonding, high surface strength, dimensional stability, lack of curl, freedom from fuzz and foreign surface material	book papers, magazine, all kinds of papers suitable for use with offset lithography	P.H. Gladfelter (Neenah, WI) Recycle 100	personal and very small businesses - distributed through Earth Care (Madison, WI)	unbleached 100% recycled content
				P.H. Gladfelter		100% pre consumer recycled content, bleached with sodium hypochlorite
				Cross Pointe (Miami, OH) uncoated free sheet	commercial - used in outdoor fashion/equipment catalogues	60% average recycled content, bleached with sodium hypochlorite
				Steinbeiss (Germany) Recyconomic	commercial - distributed by International Paper (US), and by Recycled Paper Company	unbleached or hydrogen peroxide bleached non-deinked 100% recycled paper.
				Domtar	personal - distributed by Atlantic Recycled Paper Co.	100% postconsumer recycled content, non-deinked, unbleached

Table 4.1 Paper and Paperboard Grades Containing Virgin Bleached Pulp^a and Commercially Available Unbleached or Alternatively Bleached Products

Paper Grade ^{b,c}	Percent of Total Bleached Kraft Virgin Pulp Use ^a	Desired Qualities ^b	Major Uses of Paper Grade ^b	Examples of Commercially Available Unbleached or Alternatively Bleached Products ^d	Major Purchasers ^d	Alternative Process Used ^{d,e}
				Holman printing paper	personal and commercial - supplied by American Paper sales to mainly nonprofits and universities for newsletters, magazines, etc.	Oxygen bleached virgin paper
White Wove Envelope	3	strength, smooth fold, strength at crease, good printability, lack of tendency to curl or cockle	envelopes	Domtar	personal - distributed by Atlantic Recycled Paper Co.	100% postconsumer recycled content, non-deinked, unbleached
				Tri-State	personal - distributed by Atlantic Recycled Paper Co.	100% recycled content, unbleached
				Steinbeiss Recyconomic	personal - distributed by Atlantic Recycled Paper Co.	100% recycled, bleached with hydrogen peroxide
Tablet	1	fairly good writing surface, uniform caliper, resistant to erasing abrasion	writing tablets	Diversified Packaging Products writing tablets	personal consumers - distributed through Seventh Generation (Colchester, VT)	unbleached recycled paper
				FSC Paper legal pads	personal - distributed by Atlantic Recycled Paper	100% postconsumer recycled paper unbleached or bleached with hydrogen peroxide
Thin Papers	1		carbon paper, cigarette paper, condenser paper, Bible paper, manifold paper			

Table Paper and Paperboard Grades Containing Virgin Bleached Pulp^a and Commercially Available Unbleached or Alternatively Bleached Products

Paper Grade ^{b,c}	Percent of Total Bleached Kraft Virgin Pulp Use ^a	Desired Qualities ^b	Major Uses of Paper Grade ^b	Examples of Commercially Available Unbleached or Alternatively Bleached Products ^d	Major Purchasers ^d	Alternative Process Used ^{d,e}
<u>Bleached Bristol</u>	4		index cards, records, cards, menus, announcements, folders, advertising cards	Domtar file folders		unbleached 100% postconsumer recycled paper
<u>Coated Bristol</u>	1		posterboard and postcards			
<u>Bleached Packaging Papers</u>	2					
<u>Bag and Sack</u>	1	durability	grocery bags, sack paper			
<u>Specialty Packaging</u>	2					
<u>Tissue</u>	13	softness, absorbency, cleanliness, adequate strength				
Toilet	5	softness, absorbency, cleanliness, adequate strength	toilet paper	Fort Howard (Green Bay, WI) Product 100	mainly commercial, some personal consumers - distributed in stores, catalogs, and to large companies by distributors and brokers, i.e., Recycled Products Company and Atlantic Recycled Paper	unbleached 100% postconsumer recycled content
				Wisconsin Tissue (Menasha, WI) Second Nature and Seventh Generation lines	personal - distributed by Seventh Generation among others	unbleached recycled paper
				Sorg (Middleton, OH)	institutional purchasers	unbleached, non-deinked 100% recycled content
				Scott Paper (Vancouver)	commercial	hydrogen peroxide or unbleached

Table 4.1 Paper and Paperboard Grades Containing Virgin Bleached Pulp^a and Commercially Available Unbleached or Alternatively Bleached Products

Paper Grade ^{b,f}	Percent of Total Bleached Kraft Virgin Pulp Use ^c	Desired Qualities ^b	Major Uses of Paper Grade ^b	Examples of Commercially Available Unbleached or Alternatively Bleached Products ^d	Major Purchasers ^d	Alternative Process Used ^{d,e}
				Orchid Paper Co. (La Palma, CA) Careline ^g	personal and commercial - distributed by Asdun Industries and Today's Choice	hydrogen peroxide or unbleached
				Fort Howard Envision	mainly commercial, some personal consumers - distributed in stores, catalogs, and to large companies by distributors and brokers	100% recycled content bleached with sodium hypochlorite
Facial	1	softness, absorbency, cleanliness, adequate strength	facial tissue, toilet paper, paper napkins, professional towels, industrial wipes, hospital items	Fort Howard Product 100	mainly commercial, some personal consumers - distributed in stores, catalogs, and to large companies by distributors and brokers	unbleached 100% postconsumer recycled paper
				Fort Howard Envision	commercial and personal	100% recycled content bleached with hypochlorite
				Wisconsin Tissue, Second Nature, and Seventh Generation	personal and commercial - distributed by Seventh Generation, retailed commercially to commercial and industrial users by WT	hydrogen peroxide bleached and unbleached 100% recycled content

Table 4 Paper and Paperboard Grades Containing Virgin Bleached Pulp^a and Commercially Available Unbleached or Alternatively Bleached Products

Paper Grade^{b,f}	Percent of Total Bleached Kraft Virgin Pulp Use^c	Desired Qualities^b	Major Uses of Paper Grade^b	Examples of Commercially Available Unbleached or Alternatively Bleached Products^d	Major Purchasers^e	Alternative Process Used^{d,e}
Napkins	2	softness, absorbency	napkins	Fort Howard Product 100	mainly commercial, some personal consumers - distributed in stores, catalogs, and to large companies by distributors and brokers	unbleached 100% recycled content
				Fort Howard Envision	mainly commercial, some personal consumers - distributed in stores, catalogs, and to large companies by distributors and brokers	100% recycled content bleached with hypochlorite
				Wisconsin Tissue Second Nature and Seventh Generation dinner napkins	personal and commercial - distributed by Seventh Generation, retailed commercially to commercial and industrial users by WT	hydrogen peroxide bleached 100% recycled content
				Orchid Paper Co. Careline^g	personal and commercial - distributed by Asdun Industries and Today's Choice	hydrogen peroxide or unbleached

Table 4.1 Paper and Paperboard Grades Containing Virgin Bleached Pulp^a and Commercially Available Unbleached or Alternatively Bleached Products

Paper Grade ^{b,1}	Percent of Total Bleached Kraft Virgin Pulp Use ^c	Desired Qualities ^b	Major Uses of Paper Grade ^b	Examples of Commercially Available Unbleached or Alternatively Bleached Products ^d	Major Purchasers ^d	Alternative Process Used ^{d,e}
Toweling	4	fast absorbency, water holding capacity, tear resistance, softness, freedom from lint and unpleasant odors	roll and fan folded	Fort Howard Product 100	personal and commercial consumers - distributed in stores, catalogs, and to large companies by distributors and brokers i.e., Recycled Products Company and Atlantic Recycled Paper	unbleached 100% postconsumer recycled content
				Fort Howard Envision	mainly commercial, some personal consumers - distributed in stores, catalogs, and to large companies by distributors and brokers	unbleached or bleached with hypochlorite 100% recycled content
				Wisconsin Tissue Seventh Generation	personal - distributed by Seventh Generation	unbleached recycled paper
				Wisconsin Tissue	commercial - retailed by WT to airports, restaurants, industry	bleached with hydrogen peroxide recycled paper
				Scott Paper		hydrogen peroxide or unbleached recycled paper
				Orchid Paper Co. Careline ^f	personal and commercial - distributed by Asdun Industries and Today's Choice	hydrogen peroxide or unbleached

Table 4 Paper and Paperboard Grades Containing Virgin Bleached Pulp* and Commercially Available Unbleached or Alternatively Bleached Products

Paper Grade ¹	Percent of Total Bleached Kraft Virgin Pulp Use ²	Desired Qualities ³	Major Uses of Paper Grade ⁴	Examples of Commercially Available Unbleached or Alternatively Bleached Products ⁵	Major Purchasers ⁶	Alternative Process Used ⁷
				Tagson	personal - distributed to consumers through catalog and health food stores by Atlantic Recycled Paper	recycled paper, unbleached or bleached with hydrogen peroxide
				Wisconsin Tissue Seventh Generation	personal and commercial - distributed to consumers through Seventh Generation catalog, retailed commercially by WT	bleached with hydrogen peroxide recycled paper
Other Sanitary Tissue	1	absorbent, bulky	used for sanitary, disposable purposes	Fort Howard Product 100 handiwipes	mainly commercial, some personal consumers - distributed in stores, catalogs, and to large companies by distributors and brokers	unbleached 100% postconsumer recycled paper
				Fort Howard Envision handiwipes	mainly commercial, some personal consumers - distributed in stores, catalogs, and to large companies by distributors and brokers	100% recycled content bleached with hypochlorite
				Defoe and Defoe (Canada) diapers	personal - distributed by Seventh Generation	recycled paper, bleached with hydrogen peroxide

Table 4.1 Paper and Paperboard Grades Containing Virgin Bleached Pulp^a and Commercially Available Unbleached or Alternatively Bleached Products

Paper Grade ^{a,f}	Percent of Total Bleached Kraft Virgin Pulp Use ^a	Desired Qualities ^b	Major Uses of Paper Grade ^b	Examples of Commercially Available Unbleached or Alternatively Bleached Products ^d	Major Purchasers ^d	Alternative Process Used ^{d,e}
				Total Marketing Co (Pleasant Hill, CA) sanitary napkins	personal - distributed by Today's Choice	recycled paper, bleached with hydrogen peroxide
				Universal Health Care Products (Canada) sanitary napkins	personal - distributed by Seventh Generation	recycled paper, hydrogen peroxide bleached
				Melitta coffee filters	personal and commercial	unbleached
				Mr Coffee coffee filters	personal and commercial	bleached without molecular chlorine
				Natural Brew (Little Rapids, Little Rapids, WI) coffee filters	personal and commercial - distributed by Rockline (Sheboygan, WI)	unbleached
Solid Bleached Paperboard	16			Careline (Orchid Paper Co., La Palma, CA) coffee filters	personal and commercial - distributed by Asdun Industries and Today's Choice	hydrogen peroxide or unbleached
Linerboard	1		used as the facing material in corrugated or solid fiber shipping containers	Inland Container Corporation (Ontario, CA)	commercial	Monox-L with virgin pulp
Folding Carton Type Board	7	foldability, appearance, stiffness	boxes set up, filled, and used by the end user	Inland Container Corporation	commercial	Monox-L with virgin pulp
Milk Carton and Food Service	5	strong, tough, waterproof, usually plastic coated, able to be formed into cartons, taste	cartons for milk and other liquid beverages, butter, ice creams	ASSI (Sweden) milk cartons	commercial and personal	unbleached virgin pulp
Other	1			Glenn Foods (NY) lollipop stick	personal	unbleached virgin pulp

Table 4 Paper and Paperboard Grades Containing Virgin Bleached Pulp^a and Commercially Available Unbleached or Alternatively Bleached Products

Paper Grade ^{b,c}	Percent of Total Bleached Kraft Virgin Pulp Use ^a	Desired Qualities ^b	Major Uses of Paper Grade ^b	Examples of Commercially Available Unbleached or Alternatively Bleached Products ^d	Major Purchasers ^d	Alternative Process Used ^{d,e}
Exports	2					
Medium Bleached Pulp Content (30 to 74.9 percent of total fiber)						
Coated Groundwood	6	printing quality, color, smoothness, opacity, quality surface	commercial printing for high quality advertising, brochures, magazines, books	Weyerhaeuser (US)	commercial - light magazine grade	100% chlorine dioxide substituted virgin paper
Special Industrial Papers	3		papers intended for industrial uses			
Low Bleached Pulp Content (0 to 29.9 percent of total fiber)						
Newsprint	6		newspapers, catalogs, directories			
Uncoated Groundwood	1		low cost printing paper			

Sources:

^a Only those grades containing greater than one percent of total bleached kraft virgin pulp produced in the U.S. are included.

^b API. 1980. The Dictionary of Paper. 4th ed. NYC: API

^c Table 2.10, Table 2.19

^d Information from phone conversations conducted by Abt Associates July/August 1990 and February/March 1992.

^e Reduced levels are being achieved by: using recycled fibers without rebleaching, using recycled fibers with reduced bleaching, bleaching with a chlorine alternative such as hydrogen peroxide or oxygen, or bleaching with a chlorine derivative, such as hypochlorite or chlorine dioxide in place of molecular chlorine.

^f Shaded paper grade categories indicate major grades. Unshaded paper grade subcategories follow shaded categories.

^g Reference was unclear whether or not Carline products contained recycled paper.

molecular chlorine by using recycled paper as a feedstock and either not rebleaching or rebleaching with sodium hypochlorite or hydrogen peroxide.

Paper recycling and alternative bleaching are linked for at least two reasons. First, recycled paper feedstocks that have been bleached once do not require nearly as much bleaching as virgin feedstocks to achieve the same brightness levels. Mills using recycled paper as a feedstock can use weaker bleaching chemicals, or smaller amounts of bleaching chemicals, than would be required to bleach virgin pulp. By using non-deinked recycled pulp as a feedstock, virtually any pulp and paper mill can produce unbleached pulp or paper without major conversion costs or time delays (Resource Recycling, May 1990).

Second, consumers demanding unbleached or alternatively bleached paper often also want recycled paper. So far, the primary consideration for environmental consumers has been recycled content, with the bleaching process being an important, but secondary, consideration.

Although not exhaustive, Table 4.1 indicates the presence of many unbleached or alternatively bleached paper products in the United States as of early 1992, many of which exist in categories of paper that have typically been chlorine bleached.

Conclusions that can be drawn from Table 4.1 include the following:

- There are unbleached or alternatively bleached products in each of the three paper categories currently using large quantities of bleached virgin kraft pulp.
- Alternative products sold in the United States are being produced domestically, as well as in Canada and Europe.
- Reduced molecular chlorine use in pulp bleaching is being achieved by:
 - using recycled fibers without rebleaching;
 - using recycled fibers and bleaching with fewer chemicals than are required to bleach virgin fibers;
 - bleaching with a chlorine compound (e.g., sodium hypochlorite); and
 - bleaching with a chlorine alternative, (e.g., hydrogen peroxide and oxygen).

The following subsections describe only the paper grades listed in the table for which unbleached or alternatively bleached products were identified.²

4.1.1 Coated Free Sheet

Coated free sheet uses 10 percent of the bleached kraft virgin pulp used in the United States. Its main use is for printing in high quality advertising, brochures, magazines, and books. Desired qualities include good printability, color, smoothness, opacity, and a quality surface (API, 1980). Mohawk Paper Mills is developing an unbleached or hydrogen peroxide rebleached coated free sheet from recycled paper.

4.1.2 Uncoated Free Sheet

Uncoated free sheet is the single largest user (35 %) of the bleached kraft virgin pulp used in the United States. It includes bond and writing, form bond, carbonless, cover and text, offset, white wove envelope, and tablet papers. Used mainly for printing, writing, and related applications, historically the desired qualities of uncoated free sheet included printability, color, smoothness, opacity, quality surface and permanence (API, 1980). With the advent of widespread computer use, however, much of the uncoated free sheet used by universities, businesses, and the government is for short term, disposable uses, such as draft reports or internal memos. These purposes do not require the extremely high brightness or permanence of high quality papers, and represents a large potential market niche for alternatively bleached or even unbleached paper (H.A. Simons, 1991).

Current producers and distributors are having varying success in selling alternatively bleached or unbleached uncoated free sheet. A distributor of printing papers found unbleached grey paper "really hard to sell" to mainstream commercial businesses. He found, however, that selling MCF bleached paper was much easier. He felt that "people would love to buy totally chlorine-free bleached alternatives that gave them the quality they wanted if that was an option". A spokesman from Earth Care indicated that all of their unbleached or alternatively bleached paper lines were quite successful among environmental consumers. In fact, their Minimum Impact paper line (unbleached, 100% post-consumer recycled content) was their top seller, used mainly by environmentalists and nonprofits for producing their newsletters.⁷

Bond and Writing Papers

Bond and writing papers comprise nine percent of the bleached kraft virgin pulp used in the United States. These papers are characterized as having superior strength, performance,

²Additional grades for which no products were found are omitted from the discussion; therefore, percentages may not sum to total usages expressed in Section 4.1 subsections.

⁷For a more detailed discussion of consumer and commercial markets, see Section 4.2.

durability, printability, erasability, whiteness, cleanliness, freedom from fuzz, uniform finish, and good formation (API, 1980). Historically, bond and writing papers were used for legal documents, bonds, stationery, insurance policies, letterheads, business forms, data sheets, collection books. Now, however, the bond and writing papers also include office paper such as copy and printer paper (API, 1980). Manufacturers of alternative products include Alte Schule, Domtar, Holman, Cascades, Inc., James River, and Rolland, Inc. Most of the alternatively bleached papers are made from recycled paper feedstocks and are either unbleached, unbleached, or rebleached with hydrogen peroxide. In addition, Domtar adds grey or cream dye to its non-deinked unbleached recycled pulp to obtain a consistent color. Holman, a Swedish paper company, is one of the few producers found to make paper by using virgin pulp bleached with hydrogen peroxide. The American distributor of the paper, American Paper Sales, has reported a substantial increase in demand for the paper in 1990. The main purchasers of the paper have been environmental magazines and universities.

Seventh Generation, a catalog company selling environmentally friendly products, has decided to drop its entire line of recycled and alternatively bleached office papers. A spokeswoman from Seventh Generation felt that the line did poorly not because people were uninterested in recycled and alternatively bleached papers, but because too many conventional office suppliers had gotten into the market niche. As she explained, "lots of people sell environmental lines at this point; it's no longer lucrative for our catalog".

Paper in Motion, a distributor of recycled bleached, unbleached, and hydrogen peroxide bleached office papers to large companies, found that large corporations tended to purchase bleached paper out of habit and a belief that whiter is better. Wholesalers, however, are often more willing to buy tan or unbleached paper.

Cover and Text Paper

Cover and text papers account for one percent of the bleached kraft virgin pulp used in the United States. Cover papers require good folding qualities, printability, and durability. They are used for book, magazine, and catalog covers, as well as for brochures, photomounts, and pamphlets. Text paper requires fine quality and texture for printing, and is used for advertising, booklets, brochures, announcements, fine books, annual reports, menus, and folders (API, 1980). Several examples of alternatively bleached cover and text papers contained recycled paper feedstocks either unbleached or bleached without chlorine. Two of the sample manufacturers of the alternatively bleached cover and text paper did not deink the pulp.

As with other writing and printing papers, the success of marketing cover and text papers depends on the type of purchaser, and whether or not the paper is bleached. A distributor that targets environmental consumers and sells only recycled and mainly unbleached papers said the paper lines are "very successful; this is what people are looking for". Even among staunch environmentalists, however, there is still a desire for white paper. In 1990 Greenpeace, for example, reported using sodium hypochlorite bleached white paper for their magazine because they found that color photos did not show up well on off-white paper.

Offset Paper

Offset paper uses nine percent of the bleached kraft virgin pulp used in the United States. It is characterized as having good internal bonding, high surface strength, dimensional stability, lack of curl, and freedom from fuzz and foreign surface material. As the name implies, offset papers are used in offset lithography to produce books, magazines, and other printed materials (API, 1980).

The unbleached and alternatively bleached offset papers found were manufactured in Germany (Steinbeiss), Canada (Domtar), Sweden (Holman), and the United States (P.H. Gladfelter, Cross Pointe). All papers except Holman's were produced from recycled paper feedstocks, and were either unbleached or rebleached with sodium hypochlorite or hydrogen peroxide.

White Wove Envelope

White wove envelope uses three percent of the bleached kraft virgin pulp used in the United States. It requires qualities of strength, smooth fold, strength at crease, good printability, and lack of tendency to curl or cockle. As its name implies, the paper grade is used to make envelopes. Domtar, Tri-State, and Steinbeiss manufacture alternatively bleached envelopes sold in the United States. All three make envelopes from unbleached recycled paper feedstocks; Steinbeiss also produces a hydrogen peroxide bleached recycled paper line.

Tablet

Tablet paper uses one percent of the bleached kraft virgin pulp used in the United States. Made into writing tablets, it requires a fairly good writing surface, uniform caliper, and resistance to erasing abrasion (API, 1980). Two alternatively bleached writing tablets were found: one made of unbleached recycled paper, and another with unbleached or hydrogen peroxide rebleached dyed recycled paper. Both are sold mainly to environmental consumers through catalogs; the unbleached, undyed paper reportedly sold poorly, while the yellow-dyed paper sold well. Seventh Generation found that their unbleached undyed writing paper, now discontinued, did not sell well because "it's grey and it soaks up ink. People don't like using it".

4.1.3 Tissue

Tissue papers use 13 percent of the bleached kraft virgin pulp used in the United States. Desired qualities include softness, absorbency, cleanliness, and adequate strength. Bleached tissue is used to make toilet tissue, facial tissue, napkins, paper towels, and other sanitary tissue.

To date, tissue grades have been the most successful grades among the unbleached and alternatively bleached commercially available products. Alternatively bleached tissues have sold

particularly well to commercial purchasers and environmentally concerned consumers. Several companies that target environmental consumers report that their unbleached and hydrogen peroxide bleached tissues are their top sellers. In addition, Wisconsin Tissue, which produces hydrogen peroxide rebleached recycled tissue, napkins, and paper towels, reported strong success selling to commercial and institutional purchasers.

The mainstream retail market, however, still demands bright white tissue. Wisconsin Tissue uses chlorine bleach for some products they retail because they cannot get products sufficiently white with hydrogen peroxide and "consumers demand it". Sorg Paper Company also found that institutional purchasers are more tolerant than retail customers of tissue that is less bright or white. Sorg produces toilet paper from unbleached, non-deinked recycled pulp.

As a spokesman from Total Marketing Co. (a tissue manufacturer) explained, "In our business, clean and sanitary translates to white". Although they have recently introduced a line of hydrogen peroxide bleached products, they find that most consumers are not concerned with the difference in bleaching process. "[People] would rather buy the Bounty brand of paper towels with polyester fibers for strength than buy a lesser performing environmental brand". In sum, the general public still wants soft, white tissue. For alternatively bleached tissues to gain a larger market share, manufacturers must either produce products of the same quality as those produced with molecular chlorine, or they must convince retail consumers to accept off-white tissue.

Because tissue manufacturing in the United States is highly concentrated, any change in marketing will depend on the actions of a small number of companies. The top five companies control 75 percent of the market; the top ten companies control 93 percent of the market (Canadian Forestry Service, 1988) (see Table 4.2). The top companies have a reputation as "the world's leaders in tissue paper machine technology, converting technology and innovative marketing" (Canadian Forestry Service, 1988). If the top 10 tissue producers were to convert to totally chlorine-free (TCF) bleaching technologies, the tissue market would shift dramatically, decreasing the use of bleached kraft pulp in the United States by approximately 12 percent. Several of the top producers, notably Fort Howard and Scott Paper, already produce unbleached and alternatively bleached tissue lines.

Table 4.2
Top Ten United States Tissue Producers, 1987

Company	Capacity (1000 tpy)*	Market Share (%)
Scott Paper	940	18.3
James River	916	17.9
Proctor and Gamble	816	15.9
Fort Howard	771	15.0
Georgia-Pacific	490	9.6
Kimberly-Clark	393	7.7
Erving Paper Mills	136	2.7
Pope and Talbot	134	2.6
Chesapeake	100	1.9
APL	86	1.7
Total for Top Ten	4,782	93.3
Source: Canadian Forestry Services, 1988. Table 6.2.		
* tpy = tons per year.		

Toilet

Toilet tissue uses five percent of the bleached kraft virgin pulp used in the United States. Its desired qualities include softness, absorbency, cleanliness, and adequate strength. Distributors found that mainstream consumers decided unbleached toilet tissue was not soft enough, nor looked "clean" enough, as defined by its whiteness. As one distributor explained, "only the diehards buy grey toilet paper". Another distributor who wanted to carry unbleached toilet tissue was discouraged from doing so by other suppliers who said it did not sell well. However, as mentioned before, unbleached and alternatively bleached tissues, including toilet tissue, were top sellers for distributors selling to environmental consumers. The unbleached toilet tissues found in this investigation were all made from unbleached recycled paper, and appear to be sold mainly to environmental and commercial or institutional buyers. Toilet tissues made from virgin or recycled pulp bleached with hydrogen peroxide or sodium hypochlorite have entered the mainstream retail market as well.

Facial

Facial tissue comprises one percent of the kraft bleached virgin pulp used in the United States. Similar to toilet tissue, its desired qualities include softness, absorbency, cleanliness, and adequate strength. The issues of whiteness and softness that apply to toilet tissue also apply to facial tissue, and the purchasers appear to be the same as well. Most of the facial tissues found were made from recycled pulp, and were either unbleached, or rebleached with hydrogen peroxide or sodium hypochlorite. The tissues are being sold to both personal and commercial purchasers.

Napkins

Napkins make up two percent of the kraft bleached virgin pulp used in the United States. They require softness and absorbency. The same producers making unbleached or alternatively bleached toilet and facial tissues also make unbleached or alternatively bleached napkins. The napkins found were generally sold on the commercial market, with some personal consumers as well.

Toweling

Paper toweling makes up four percent of the kraft bleached virgin pulp used in the United States. It requires fast absorbency, water holding capacity, tear resistance, softness, and freedom from lint and unpleasant odors. Towels are sold in rolls or fanfolded for the personal and commercial markets. As with napkins, paper towels are made as a part of an unbleached or alternatively bleached tissue line. Most of the paper towels found used recycled paper feedstocks and either did not rebleach or rebleached with hydrogen peroxide or sodium hypochlorite. Wisconsin Tissue noted that the whiteness standards for toweling were lower than for napkins, stating, "People are more willing to accept a high dirt count in brown paper toweling than in napkins".

Other Sanitary Tissue

Other sanitary tissues make up one percent of the kraft bleached virgin pulp used in the United States. Absorbent and bulky, they are used for sanitary, disposable purposes. Products included in this category include handwipes, diapers, sanitary napkins, and coffee filters.

Unbleached coffee filters have been particularly successful in mainstream markets. For example, Melitta began marketing unbleached coffee filters in July, 1989. After only 10 months on the market, the unbleached filters accounted for 15 to 20 percent of all of Melitta's coffee filter sales, and as much as 50 percent in some west coast markets (U.S. EPA, 1990a). A paper manufacturer said that all coffee filter manufacturers are moving away from molecular chlorine bleaching processes, mainly to chlorine dioxide.

4.1.4 Solid Bleached Paperboard

Solid bleached paperboard is another significant use of kraft bleached virgin pulp, accounting for 16 percent in the United States. This category includes linerboard, folding carton type board, milk cartons and food service, and miscellaneous paperboard. Several sources have pointed out that molecular chlorine was not necessary to achieve the desired qualities required by the market. One paper expert from Resource Recycling states that "there is generally no reason to use bleached board". The exception to this is for very greasy foods and milk where the FDA has concerns over contaminant leaching.

Inland Container Corporation is switching to a MCF MONOX-L⁸ bleaching system for its entire production of bleached virgin pulp and paperboard. Because they have found no difference in quality between the products bleached with MONOX-L and those bleached with molecular chlorine, they find that their MCF products occupy the same market niche as the molecular chlorine bleached products did. Inland did not feel any impetus to advertise the change because they found that people were more concerned with recycled content than with bleaching processes.

Linerboard

Linerboard makes up one percent of the bleached kraft virgin pulp used in the United States. It is used as the facing material in corrugated or solid fiber shipping containers. Desired qualities include strength and durability. The percentage of the materials being bleached has been increasing in order to include advertising print on boxes. Inland Container Corporation makes virgin bleached linerboard without using molecular chlorine.

Folding Carton Type Board

Folding carton type board makes up seven percent of the bleached kraft virgin pulp use in the United States. It is used to make boxes that are set up, filled, and used by the end user. Requirements include foldability, appearance, and stiffness. Inland also makes virgin bleached folding carton type board without using molecular chlorine.

⁸MONOX-L is hypochlorous acid (HClO) plus an additive developed and patented by Quantum Technologies. Hypochlorous acid (L), the hydrated form of chlorine monoxide, has been known since the 1930s as an excellent bleach chemical, however, it has not been used as it is destructive to the pulp. Quantum's developed additive maintains bleaching characteristics without pulp destruction. In many ways, MONOX-L can be compared to chlorine dioxide due to its bleaching condition and abilities. The process equipment metallurgy required for MONOX-L is reported to be the same as that needed for chlorine dioxide (U.S. EPA, 1990b).

Milk Carton and Food Service

Milk carton and food service paperboard use five percent of the kraft virgin pulp made in the United States. Usually plastic coated, it is required to be strong, tough, waterproof, able to be formed into cartons, and flavorless. These cartons are used to hold liquids and foods such as milk, juices, butter, and ice cream.

Although unbleached milk cartons are produced and used in Sweden, no unbleached or alternatively bleached milk cartons were found in the United States. Based on conversations with the Milk Industry Foundation and one dairy, there appears to be a belief that the paper industry has successfully eliminated risk resulting from dioxin leaching from milk cartons to milk. Given this understanding, these two sources were not concerned with developing further changes in the bleaching method used for milk cartons. According to the United States Food and Drug Administration, the most exposed individual's risk from leached dioxin into milk is below one in one million cases per lifetime.

Given that mill effluents or sludge may result in increased environmental or health risks, however, the question remains whether or not molecular chlorine bleached milk or food cartons are required. According to STFI, a Swedish corporation, milk cartons used in Sweden are no longer bleached with molecular chlorine; oxygen, chlorine dioxide, and/or hydrogen peroxide are used to bleach the cartons. Another Swedish company, ASSI, produces milk carton grades that are completely unbleached. ASSI coats the unbleached cartons with clay to achieve a bright surface and coats the interior to avoid any imparted taste from the paper. They have experienced no problems with taste for milk sold in unbleached cartons, a stated concern of American producers.

In addition to concern about possible taste problems, there is the perception in the United States that white is clear and pure. As a United States dairy representative commented, "The whiteness of the carton elaborates on the purity of the milk. White milk from a brown carton is unappealing". The Swedish experience, however, demonstrates that 1) molecular chlorine is not needed to produce white cartons, and 2) a consumer market exists that is receptive to unbleached milk cartons. The acceptability of unbleached milk cartons in the United States is as yet unknown.

4.1.5 Coated Groundwood

Coated groundwood uses six percent of the kraft virgin pulp made in the United States. It is characterized as having good printing quality, color, smoothness, opacity, and a quality surface. This paper is used for commercial printing for high quality advertising, brochures, magazines, and books. The only alternatively bleached paper in this grade found was a light magazine grade made by Weyerhaeuser, with chlorine dioxide bleached virgin paper.

4.1.6 Newsprint

Newsprint uses six percent of the kraft virgin pulp made in the United States. It is mainly used to print newspapers, flyers, catalogs, and directories. Newsprint has low bleaching requirements, and is composed of approximately 25 percent bleached pulp and 75 percent unbleached pulp (see Table 2.10). Because newsprint does not require high brightness, it can be readily produced without molecular chlorine. Some newspapers, however, such as USA Today, are starting to use "improved" or "upgraded newsprint" requiring increased brightness and opacity. The demand for "improved" newsprint is expected to grow as newspapers increasingly compete with television for an audience (Canadian Forestry Service, 1988). One source suggested combining thermomechanical pulping with hydrogen peroxide bleaching and *inorganic fillers to achieve the higher standards without using chlorine* (Canadian Forestry Service, 1988).

4.2 Paper Market: Consumer Groups

The paper market can be divided into two main consumer groups: personal and commercial. The personal market includes papers purchased through retail outlets or catalogs for home and office use. The commercial market includes all types of paper and paperboard grades bought wholesale or retail for businesses and institutions. The distinguishing feature between the two is that the personal market is composed of individual consumers buying small quantities for personal use, while the commercial market is characterized by professional procurers buying large quantities of paper. For some consumers, such as small businesses, this distinction is blurred.

4.2.1 The Personal Market

Comments from distributors who sell paper through retail outlets or catalogs to personal consumers illustrated two distinct personal consumer markets. One group, a small, very environmentally-aware segment of the population, buys MCF or TCF bleached paper out of a concern for and commitment to environmental and health issues. They actively seek out and request unbleached or alternatively bleached products, particularly for printing and writing papers and tissue papers. One consumer survey conducted by a paper distributor found them to be "more affluent, well-educated, environmentally conscious consumers". For them, "unbleached tissue is the number one seller in [our] whole catalog". In fact, the distributor reported receiving many calls requesting unbleached paper before they carried it. Earth Care, a paper distributor that targets environmental consumers, reports that its best selling product is its Minimum Impact line, a 100 percent post consumer unbleached recycled paper. The general public, however, is not aware of or concerned with the differences in bleaching processes. Unbleached grey paper alternatives are very hard to sell to this group.

4.2.2 The Commercial Market

Distributors felt that small- and medium-sized corporations are concerned that using grey or off-white paper would hurt their image. Exceptions can be found in some nonprofits and outdoor equipment retailers. In addition, one commercial distributor found that wholesalers were often more willing than large businesses to buy unbleached paper. A very large corporation with an established market share could use the switch to unbleached or alternatively bleached paper as a public relations tool to enhance its environmental image. McDonalds, for example, has enhanced its image by switching to unbleached recycled paper packaging.

In addition to a concern with image, distributors said that inertia plays a role in American companies' failure to switch to unbleached or alternatively bleached paper. For example, although most of the high quality paper purchased by an office is used internally (and therefore does not affect a corporation's public image), companies are not used to buying or using unbleached or alternatively bleached paper. The perception that "white is better", coupled with a lack of knowledge of or concern with paper bleaching processes, inhibits the switch to MCF or TCF office paper, even for uses where white paper is not essential (such as draft reports or internal memos). Several experts felt that it would take the very large corporations to establish a trend by switching to unbleached or alternatively bleached paper before the small- and medium-sized companies would feel comfortable doing so.

4.3 Paper Market: Unbleached versus Alternatively Bleached

Demand for unbleached paper differs from demand for papers bleached with alternative processes. The only group in the United States shown to be buying unbleached grey paper products is what one distributor termed the 'diehards'. This group will actively seek out unbleached or alternatively bleached paper products out of a concern that chlorine bleaching is linked to dioxin production. For this group, paper that is unbleached is a value-added commodity, and they will pay a premium to buy it.

Among personal consumers in this group, unbleached tissues are selling better than unbleached writing papers. Unbleached writing and printing papers are used mainly by nonprofit organizations for their newsletters. Personal users are characterized as those having a strong concern for the environment. As a spokesperson from Seventh Generation described them, they are the "cutting edge environmental consumer," the people who were looking for recycled content paper 5 to 10 years ago. As mentioned above, the general public is reluctant to buy grey unbleached paper because "it doesn't look right". People expect white paper even on products where bleaching does not affect the function of the product (i.e., file folders).

Distributors agreed that alternatively or bleached products outsell unbleached papers. In general, unbleached writing and printing papers have more market limitations than do alternatively bleached paper. They are limited to fewer paper grades; i.e., they cannot be sold as the highest brightness papers, and they reportedly do not work with some copiers.

Alan Rooks from the Paper Industry Management Association felt that the first unbleached products to be accepted by the general public would be "sensitive" products perceived to directly affect human health: coffee filters, diapers, etc. In fact, unbleached coffee filters have done quite well among the general public (e.g., Melitta, Rockline Natural Brew Coffee Filters). According to one manufacturer, all coffee filter producers are voluntarily moving away from molecular chlorine bleaching.

Surprisingly, many companies are choosing not to advertise their products as unbleached or alternatively bleached. In the majority of paper catalogs examined, no mention was made of bleaching processes, even in cases where the bleaching agent was not chlorine or the product was unbleached. Paper manufacturers may be reluctant to highlight any aspect of the bleaching process, particularly if most of them are switching processes, thus eliminating any competitive advantage. In addition, many manufacturers are producing chlorine bleached products in addition to MCF or TCF products and may therefore be hesitant to publicize the chlorine issue and risk reflecting negatively on their other products. One paperboard manufacturer said that his company did not advertise their conversion to MCF bleaching because he thought that it was not a strong enough selling point.

H.A. Simons, a Canadian research firm, and AF-IPK, a Swedish company, are currently preparing a comprehensive analysis of the future of paper markets (H.A. Simons, 1991). Their summary of the potential market for alternatively bleached paper products is as follows:

In markets such as North America and Western Europe, there are signs that consumers are, increasingly, favoring papers made from TCF bleached pulp. We believe this trend is going to grow worldwide. However, the trend has created a significant dichotomy; more and more consumers want TCF alternatives for the higher quality grade of paper, while the market still demands its traditional high standards of performance.

Until now, technology has had only limited success reconciling these conflicting expectations. For products requiring bleached kraft pulp furnish (such as wood-free printing and writing paper, and bleached board), chlorine bleach still dominates. However, chlorine dioxide and oxygen are expected to replace this process during the next decade.

Increasingly, however, paper produced by alternative bleaching processes can match the quality and cost of conventionally bleached paper. One paperboard producer who switched from molecular chlorine bleaching to a MONOX-L system said that the quality produced by the new system was identical to the products they made with chlorine, and that the new products occupy the identical market niche. In cases where the quality and the cost of a TCF product are equivalent to the quality and cost of conventionally bleached products, the TCF product has a market advantage.

The expected decline in chlorine sales is an indication of the growing shift from chlorine to other bleaching chemicals. According to a recent announcement in Chemicalweek (3/18/92), "bleaching alternatives to chlorine — which will lose almost half its market by 1996 — including ozone, enzymes, and electrolytes, will grow to almost \$1.8 billion [in 1996, an] almost eight percent per year growth from last year's \$1.2 billion. Chemicals used in recycling paper, especially deinking, will also grow rapidly".

As alternatively bleached paper products equal or surpass the quality standards demanded by the market,⁹ distributors expect that consumer demand will increase. One distributor felt that "people would love to buy TCF alternatives that gave them the quality they want if that was an option". Just as recycled paper products are now enjoying a wider appeal, several distributors expect that alternatively bleached papers will become more accepted and desired as mainstream consumers became more aware of the differences between bleaching processes and the availability of alternative products.¹⁰

4.4 The European Market

According to sources at the European Paper Institute (EPI) in Paris, the international pulp and paper industry finds itself involved in many major environmental concerns and controversies due to its use of 1) forest resources, 2) water, 3) chemicals, and 4) recycled material. While the degree of public concern on any specific paper related issue varies from country to country, the top five paper-related environmental concerns in Europe are:

- Acid rain and deforestation
- Paper recycling and increased use of waste paper
- Hygienic product safety
- Labeling paper grades as environmentally friendly
- The elimination of "unnecessarily" high quality paper grades

Several sources mentioned that Europe is much more accepting of off-white or grey paper and has gone further with alternative bleaching technologies than the United States. In Europe, for example, insurance companies advertise on their envelopes that their stationery is produced from TCF bleached pulp. The German Paper Industry Association (VDP) and the German Magazine Publishers (VDZ) have stated that they will use only chemical pulps bleached with low levels of molecular chlorine and produced with an adsorbable organo-halogens (AOX) discharge of less than 2kg/t (Suess, 1992). Chemical Marketing Reporter (9/24/90) reported that "tighter emission standards on chlorinated organic compounds combined with consumer worries about

⁹Note that this is affected by changing either the product quality or the market standards.

¹⁰Several sources state that demand currently exceeds supply. See section 4.5.3 for further discussion.

dioxin residues in paper products are rapidly reducing the amount of chlorine bleaching of pulp in Europe". Many European mills are switching to chlorine dioxide and, to a lesser extent, hydrogen peroxide. While chlorine dioxide is the cheaper "quick-fix" solution, pulp-makers with a longer-term view are introducing oxygen delignification. While oxygen is usually used in conjunction with a bleaching step or steps (which may include chlorine dioxide), new mills are being designed for oxygen and may not need chlorate (Chemical Marketing Reporter, 9/24/90).

The article also cites a study of bleaching in Western Europe by the Price and Pierce Group. The study predicts that West European chlorine consumption for bleaching will drop 24 percent by 1993. The current European glut of pulp could accelerate this decrease in the use of chlorine, as the makers of chlorine-bleached pulp are put at a greater competitive disadvantage in the market. In situations where excess supply exists, competition for purchasers becomes more intense and the ability to offer a product with desirable characteristics, such as being TCF, becomes more important.

The article further states that Germany has the toughest environmental regulations affecting both the paper and pulp industries, and that new emission standards were scheduled. The new standards were designed to set maximum effluent levels for AOX and biological and chemical oxygen demand. Tighter emission standards on chlorinated organic compounds, along with consumer concerns regarding dioxin residues in paper products, resulted in the total elimination of molecular chlorine bleaching in Germany by the end of 1990. As in the United States, German mills are shifting to chlorine dioxide, hydrogen peroxide, and oxygen delignification.

According to a paper presented at a recent conference on TCF, the European market for alternatively bleached paper was largely influenced by the Germans (Suess, 1992). Germany relies on sulfite pulp mills, which require less bleaching to produce high brightness and are more easily converted than kraft pulp mills to MCF bleaching technologies. When chlorine bleaching became an environmental concern, German mills switched to alternative bleaching processes. In addition, German paper mills and printers restricted AOX effluent levels in pulp and paper imported into and used in Germany. They are expected to eventually require zero AOX emissions for all paper or pulp imported into the country. This has forced mills in other countries, particularly Sweden and Finland, to convert to alternative processes or face losing the lucrative German market (Suess, 1992).¹¹ In the United States, however, there is a large kraft pulp industry, which would require relatively substantial capital investment in new equipment to change to MCF bleaching technologies. One environmental group reasoned that the lag in the use of alternatively bleached papers may be due more to industry reluctance to make costly conversions than to lack of consumer acceptance of these papers.

¹¹The government of British Columbia also recently announced regulations, put into effect July 1, 1992, requiring mills in the province to eliminate AOX produced in the bleaching process by December 31, 2002.

A second possible reason offered for Europeans' willingness to accept unbleached or alternatively bleached paper is that pollution from pulp and paper mills in Europe is more readily apparent to the public than it is in the United States. Much of the effluent from Western European industry drains into the Baltic Sea, which is mainly enclosed and slow-draining compared to the rivers and coastline of North America. Coupled with a historical lack of secondary waste treatment by European pulp and paper mills, the long local residence time of marine pollutants has had a dramatic negative impact on the Baltic Sea ecosystem. It may be that the visible pollution of the Baltic Sea has heightened the awareness of European consumers and increased the percentage of the market willing to buy unbleached paper products out of concern for the environment (Greenpeace).

Both Germany and Sweden have well developed markets for unbleached and alternatively bleached paper. Germany is very different from Sweden, however, in that Germany is a densely populated country with little forest land. Unlike the Swedish economy, in which half of the gross domestic product (GDP) is derived from pulp and paper industries, the German economy is highly diversified, with paper production being only a small fraction of GDP.

According to a report on the German pulp and paper industry, Germany produced 46 percent of its paper and paperboard using post-consumer recycled paper in 1988. Compared to Germany, United States use of recycled paper is low (26% in 1988). The Federal government of Germany supports large scale waste paper collection systems capable of sorting acceptable waste paper. Using this system, approximately five million metric tons of paper were collected and recycled in 1988. Waste paper is the fiber most used in Germany to produce paper. Fiber usage, not including additives and fillers, in Germany in 1989 as a percent of total paper and paperboard manufacture was:

Fiber Usage	
<u>Fiber Type</u>	<u>German Use¹²</u>
Waste paper	49%
Chemical pulp	35%
Mechanical pulp	16%
Source: Ver Band Deutscher Papier Fabriken, 1990.	

¹²Paper products were classified in a category if at least 50 percent of the fibers in the paper fit the category.

Germany has practiced forest management for over 150 years; conservation of healthy forest resources is not a new issue to the industry. Conversely, awareness of resource management is somewhat new to the public. Two programs that exist in Germany but not in the United States serve to support German environmentalism. One is the paper collection system described above. The other is the "Blue Angel Environmental Label", the symbol of a federally-administered labeling program for products. As of 1990, labels had not yet been awarded for TCF paper products, but the Environmental Label Jury had approved criteria by which to evaluate "paper products, whose basic constituents are manufactured without chlorine bleach" (Umweltbundesamt, 1990).

In Sweden, TCF products are also in high demand. According to a report by Pulp and Paper International (3/90, European edition), Swedish shelves are full of products displaying environmentally-friendly badges and slogans. For example, diaper boxes say "Swedish pulp. Not bleached with chlorine". Toilet paper wrappers claim "environmentally-friendly recycled paper saves the forests," and unbleached brown coffee filters are packaged with the claim "environmentally-friendly unbleached paper — for the best coffee aroma".

TCF bleached Swedish products available include:

- | | |
|-------------------------------------|---------------------------------------|
| • Toilet paper | • Coffee filters |
| • Kitchen towels | • Paper plates |
| • Disposable diapers | • Baking sheet paper |
| • Paper handkerchiefs | • Baking/Muffin paper cups |
| • Sanitary napkins/
Panty liners | • Stationary/Envelopes |
| • Paper napkins | • Printing paper |
| • Disposable face cloths | • Unglazed multiwall sack kraft paper |
| | • Milk cartons |

Note that this list covers a wide variety of types of products, from tissue to boxboard to writing paper.

The three largest Swedish paper firms, STORA, MoDo and SCA, account for 75 percent of Swedish pulp and paper production. Because these enterprises are internationally integrated and geared to export between 80 and 90 percent of their products, they are looking for markets, and market advantages, for their "clean" paper products. These consortia are primary suppliers to much of Europe's retail and wholesale markets. According to the Swedish Trade Council, all three export unbleached paper products to the United States.

4.5 Inhibiting Factors Slowing Conversion From Molecular Chlorine Bleaching

No intrinsic technological barriers to eventual production of virtually all grades of paper and paperboard without the use of molecular chlorine exist. Although admitting that the highest

brightness papers are not yet achievable without molecular chlorine, a spokesperson for Earth Care argued:

I see no reason ever to use molecular chlorine...We can satisfy 99 percent of our paper needs using alternatives...And the number of products using alternative bleaching processes is expanding all the time...I see no inherent technological barriers to eventually producing alternatively bleached products for all paper grades.

Several site-specific limitations, however, have hindered the conversion of existing mills to new technologies. In a recent survey by the EPA, chemical pulping mills were asked to list inhibiting factors that prevented them from further reducing or eliminating their chlorine use. Table 4.3 summarizes their responses. The number of responses (139) exceeds the number of mills (105) because some mills listed more than one inhibiting factor. The results listed by the chemical pulp mills can be grouped into three categories; market limitations, economic limitations, and technological limitations.

Table 4.3 Factors Inhibiting Chlorine Reduction	
Inhibiting Factors	Number of Mills
Product quality, customer satisfaction, brightness	42
Chlorine dioxide generation capacity	38
Cost	24
Equipment not available or compatible with bleach plant	17
Effluent dioxin levels already low	8
Looking into it or unsure of compatibility	4
Other	6
Source: Table 6. 1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities. Preliminary Summary Report of Questionnaire Responses for Mills that Bleach Chemical Pulps. Revised. Radian Corporation for OST/OW/U.S. EPA. 10-31-91.	

4.5.1 Market Limitations

Market limitations (e.g., product quality, customer satisfaction, and brightness) were the top inhibiting factors listed by mills. When asked to list the product specifications that inhibit chlorine reduction, the bleached pulp mills provided the answers shown in Table 4.4. Again, many mills indicated multiple constraints. As the two tables show, paper brightness is the overarching factor industry reports as inhibiting conversion to alternative bleaching processes in the United States. This is echoed in distributors' comments that "people expect paper to be white".

Table 4.4 Product Specification Constraints Inhibiting Chlorine Reduction	
Product Constraints	Number of Mills
Brightness	84
Dirt count	31
Strength	19
Cleanliness	20
Other paper property or customer acceptance	11
Viscosity	6
Shive count	3
Cost	2
None/Unknown	3
Other reason	15
Source: Table 7. 1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities. Preliminary Summary Report of Questionnaire Responses for Mills that Bleach Chemical Pulps. Revised.3 Radian Corporation for OST/OW/U.S. EPA. 10-31-91.	

Although new technologies promise to increase options for achieving high brightness levels without using molecular chlorine, several of them are still in the laboratory or pilot project stages.¹³ For existing mills, the highest brightness levels are not yet achievable without the use of molecular chlorine. Unless new technologies become available that enable existing mills to achieve these high brightness levels without molecular chlorine, a change in consumer acceptance of lower brightness papers will be the single most important determinant of whether or not mills convert their bleaching processes.

One distributor felt that to an extent, the paper industry itself encouraged current consumer preference. He found that the industry emphasized that *purity* of paper is achieved through bleaching. Distributors differed in opinion as to whether or not education would encourage consumers to buy alternatively bleached papers. Most felt that consumer understanding is quite low, and that education is critical to increasing the market for unbleached or alternatively bleached products in this country. Another distributor felt that while consumers would accept alternatively bleached products equal in quality to molecular chlorine bleached

¹³For a detailed discussion of new technologies, see: U.S. EPA Office of Pollution Prevention. 1991. *"Multimedia Analysis of Alternative Pulp and Paper Technologies -- Draft Final Report"*. Prepared by Eastern Research Group, Inc.

ones, education alone would not encourage consumers to switch to unbleached products. He explained that, "people know that junk food is bad for them, but they still buy it because they like to. They would rather buy the fluffy white toilet paper, even though they call themselves environmentalists".

4.5.2 Economic Limitations

Cost is a second major inhibiting factor discouraging mills from converting to alternative bleaching processes. While the cost of new mill construction with most new technologies is comparable to that with conventional technologies, the current cost of converting existing mills to new technologies can be prohibitively expensive (U.S. EPA, 1991a). One distributor felt that cost, not technological or market limitations, was the main reason that mills did not want to change to alternative bleaching processes.

Economies of scale exacerbate the cost question; the relatively low production levels of alternatively bleached papers currently result in higher per unit costs. Smaller brokers and mills cannot afford to sell their papers retail, where the markup is higher, because the production costs for these papers is higher. Instead, alternatively bleached papers have largely been sold wholesale and through catalogs and health food stores, rather than retailed in mainstream chains. Alternatively bleached products are beginning to appear in mainstream stores as 1) larger mills and brokers (who can afford the smaller profit margin) are selling the papers, and 2) larger volumes of alternatively bleached paper are being produced, thereby decreasing the cost per volume of the papers.

Another industry cost concern is uncertainty about regulations; they do not want to make substantial capital commitments if the new processes will later be unacceptable. One Canadian mill worried that the Canadian government would promote unbleached paper over all bleached papers. They said that the paper industry had invested millions of dollars to develop alternative bleaching processes and did not want the government to invalidate their efforts by insisting that bleached paper is unsafe. American mills that have converted their bleaching processes to increase their use of chlorine dioxide over molecular chlorine echo this concern.

A related uncertainty concerns the comparative risks of chlorine substitutes. Without risk assessments, there continue to be conflicting opinions as to whether the replacement of molecular chlorine with chlorine compounds, or reduced levels of use of molecular chlorine, are adequate industry responses to the problems posed by organochlorines. Although many manufacturers have changed or are considering changing their bleaching processes to reduce the use of molecular chlorine, the use of chlorine has persisted due to its efficiency and low cost as a raw material. Due to the cost which would be incurred to retrofit a mill for the use of TCF bleaching agents, some mills are employing chlorine compounds (e.g., chlorine dioxide and hypochlorite), or reducing the quantity of chlorine used rather than switching to a TCF-based system. For example, Westvaco Corporation has reduced the amount of chlorine they use by using chlorine in more numerous, smaller batches, and by using a lower acidity.

Risks resulting from the use of chlorine compounds, (e.g., chlorine dioxide and hypochlorite) to bleach paper have not been calculated. Further, only a few organochlorines other than dioxin have been assessed for their toxicity. It is possible that analyses will find the risk from organochlorines produced as a by-product of bleaching with chlorine compounds to be unacceptable. This view was expressed by the environmental organization, Greenpeace. Greenpeace believes that, although industry has reduced discharges of chlorinated organic chemicals, the "new levels continue to pollute massively and the capital investment in halfway measures undermines a truly preventive approach aimed at maximizing protection of the environment" (Greenpeace, 1990a). According to Greenpeace, chlorine dioxide produces about one sixth of the organochlorines produced by pure chlorine, but leads to the production of large quantities of chlorate, a powerful herbicide (Greenpeace, 1990b). Hypochlorite is linked to the production of chloroform, a suspected human carcinogen that is known to cause liver disease.

Industry perspective differs, however. Some mills are assuring their customers that hypochlorite bleaching does not create environmental problems. One mill representative stated that, "The company, along with EPA, has run tests of emissions that showed no dioxin [resulting from the hypochlorite bleaching process]". A representative of another mill said that the company has "tested their effluent from the hypochlorite bleaching process and no dioxins are detectable. Hypochlorite is like household bleach".

4.5.3 Technological and Logistical Limits

Finally, mills responding to the 1990 EPA Survey mentioned technological limitations that inhibited them from converting processes. These limitations included chlorine dioxide generation capacity, and incompatible or unavailable equipment. The EPA study indicated that many of the mills planned to eliminate these equipment limitations; this appears largely to be a short-term concern (U.S. EPA, 1991a).

A technical concern not mentioned in the mill study is that shifts in bleaching processes may require changes in other technologies, such as printing methods. Printing methods may need to be altered to achieve good results on new papers. One manufacturer of recycled, hypochlorite-bleached paper provided the paper for two major clothing companies' catalogues. For one company, he sent the uncoated paper to Japan where a color transparency process was developed for the paper. He felt that the print looked as good as it had on virgin paper. The other company used standard printing processes developed for coated paper. The ink showed increased dot gain, or spreading, and the pictures were not as clear as they had been on virgin paper. The second company printed a disclaimer on their catalogue indicating that although recycled paper did not look as good as virgin paper, using it was worthwhile and would help the environment. The problem lay not in the paper itself, but in the way in which it was combined with the printing process. To the extent that alternative printing processes are more expensive or unproven, the use of recycled and alternatively bleached printing papers will be discouraged.

A logistical concern slowing the reduction of molecular chlorine use in the United States is the lack of an infrastructure for collecting and recycling high-grade papers. As Table 4.1

shows, paper recycling and alternative bleaching are currently closely linked. Using previously-bleached, high grade recycled paper as a feedstock reduces or eliminates the need to use additional bleaching agents. Several mill representatives stated that the sporadic supply of high grade recycled papers was the major hindrance to producing a paper with high post-consumer recycled content. Apparently there is a glut of newspaper and other low-grade papers, while there is an unmet demand by the manufacturers for post-consumer office paper. One mill in California contracted for office paper with several municipalities in New Jersey, where recycling is mandatory. The mill representative said that in states without mandatory recycling, the supply of post-consumer paper was extremely erratic: "If it rains, forget it". In an effort to stabilize the supply of post-consumer paper, another mill has set up reciprocal programs with major nearby corporations. The corporations collect their paper, sell it to the mill, and are then encouraged to purchase the recycled paper. Office paper appears to be a valuable but largely wasted commodity. An infrastructure to support office paper recycling could benefit corporations by reducing disposal costs, municipalities by freeing landfill space, and paper mills by supplying a consistent secondary fiber source.

These limiting factors have led to a delayed response to the increasing demand for alternatively bleached papers. This has translated into numerous wholesalers and retailers stating that their demand for unbleached and alternatively bleached paper is unmet. In several cases, the retailers were not large enough to interest mills, who viewed the alternatively bleached products as specialty products and were unwilling to invest in new production processes required to produce the papers. Conversely, manufacturers of recycled, unbleached, and alternatively bleached papers report that their mills are at full capacity.

Wholesalers and retailers said that they were often obligated to offer chlorine bleached products when they felt that TCF products would sell well, or TCF products when they wanted to sell unbleached products. When retailers were able to obtain the paper they desired, they frequently had little flexibility and bargaining power because they were often limited to buying from a single mill. Similarly, several retailers that had been selling recycled unbleached papers stopped doing so due to the erratic supply of these papers.

Greenpeace, in searching for paper whose production results in minimal pollution, purchased oxygen-bleached paper from Holman, a Swedish company. A United States distributor of Holman's paper stated that currently the demand for TCF paper exceeds the supply. Alte Schule, a U.S. distributor of recycled, unbleached stationery, diaries, and photo albums, mentioned that they get many requests for unbleached office paper, a product they do not carry.

4.6 Future Trends

In 1988, the Canadian government published a series of reports called Canada's Forest Industry: The Next Twenty Years: Prospects and Priorities. The volume on pulp and paper predicted the structure of North American and overseas markets for bleached and unbleached

paper and paperboard products. The authors found two important potential shifts in the use of bleached papers:

- A significant proportion of the office papers produced and used is of an unnecessarily high quality. Much of the need for these papers is for short term, disposable uses; this need can be readily met using unbleached or alternatively bleached low brightness papers.
- Newsprint, historically a low bleached commodity, is being increasingly bleached for use in newspapers, such as USA Today, that employ four-color printing. Although this "improved" newsprint still comprises a small proportion of the market, its market share is expected to increase significantly.

In addition, the market for bleached paperboard in the United States is expected to increase, particularly for use as food service containers. The largest growth market in the United States is expected to be solid unbleached sulfate boxboard.

The study also described the highly concentrated, highly competitive nature of the United States tissue industry, noting that five companies control 75 percent of the market (see Table 4.2). The top United States tissue manufacturers are seen as world technological leaders, and several of them have reputations for having strong corporate environmental policies as well. Because the industry is highly concentrated and led by very large companies known to be technological innovators, conversion by industry leaders to alternative bleaching processes would change the market dramatically in a short period of time. Some of these companies, such as Fort Howard and Scott Paper, are already producing alternatively bleached and unbleached lines.

Clearly, many sectors of the paper market are changing rapidly, and the use of alternative bleaching agents and recycled paper feedstocks is increasing. According to several mills, until a few years ago paper was never advertised as recycled because recycled fibers were viewed as a liability rather than as an asset. In only the last few years, recycled fibers have been in demand. Similarly, consumer awareness of the potential drawbacks of bleached paper products has increased in the last few years. According to manufacturers and distributors, however, consumers do not yet generally recognize the difference between chlorine-bleached, MCF, and TCF papers.

Coinciding with increased consumer demand, alternatively bleached and unbleached products are beginning to be carried by large distributors and retailers. Until recently, most retailers and distributors of recycled and alternative paper products were small start-up companies; now major distributors have begun to carry them. The shift to larger distributors will potentially make recycled and alternatively bleached paper more accessible to consumers.

Over the last several years, mills have begun to respond to consumers' concerns about the use of molecular chlorine and virgin pulp in the pulp and paper industry. By 1995, the use of molecular chlorine is projected to decrease to about 25 percent of 1986-87 usage levels

(Chemical Marketing Reporter, 9/24/90). More recently, Chemicalweek predicts an even greater decline in the use of chlorine. "Chlorine will lose almost one half of its market by 1996" (Chemicalweek, 3/18/92). In addition, the American Paper Institute has announced a goal of 40 percent paper recovery by 1995. The projected conversion to non-molecular chlorine bleaching may be slowed, however, due to the current economic slowdown in the pulp and paper industry.

As indicated by the Section 308 National Census (U.S. EPA, 1991b) and echoed by comments from distributors and manufacturers, industry conversion from the use of molecular chlorine is already underway (see Chapter 1 for more discussion). Unbleached and alternatively bleached papers are enjoying commercial success in Europe and among environmental consumers in this country; demand for these papers is expected to continue to increase. Chlorine dioxide, hydrogen peroxide, and oxygen in particular are expected to replace molecular chlorine during the next decade.

As alternative bleaching technologies are increasingly developed and adopted that meet market specifications for bleached papers, alternatively bleached papers are expected to become the norm for all but perhaps the highest brightness papers. As one distributor contended, "if you [can] get a TCF bleached alternative with the same quality and price, then there [is] no reason not to buy it".

Chapter 4 References

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APPENDIX 2.A

BLEACHED AND UNBLEACHED PULP PRODUCTION VOLUMES

APPENDIX 2.A

BLEACHED AND UNBLEACHED PULP PRODUCTION VOLUMES

This section presents additional data on mill outputs compiled from self-reported data contained in the Lockwood-Post Directory of the Pulp, Paper, and Allied Trades. It includes an analysis of bleached and unbleached pulp production volumes for 99 of 104 mills in the EPA study group.

The Lockwood-Post's data used here appears to be of reasonable quality; nevertheless several caveats are necessary. First, because there is no consistent system used by mills to report their outputs, the responses may suffer from a reporting bias, i.e. mills producing the same product may describe and report it differently. Second, some mills provide production volumes while other simply list the products. Thus, aggregate production quantities are generally not available. A final problem is that some mills provide greater detail in describing their output than others. For example, one may report production of "single-ply toilet tissue" while another indicates only that "tissue" is produced. The products were coded to whatever level of detail was appropriate, given the directory entries for each mill.

Table 2.A presents data on pulp and total paper production for the 99 mills. Note that some mills do not report which type(s) of pulp are produced and others indicate the type but not the quantity. Total production of bleached pulp ranges from 150 to over 2,200 tons per day, depending on the mill. The two firms apparently most active in production of bleached pulp are Champion International, with 6 mills and 5,765 reported tpd production, and International Paper Co., which operates 9 mills and reports 5,663 tpd production.

Table 2.A

Outputs of 99 Pulp Mills From EPA's Study Group
of 104 Bleached Pulp Mills, by Firm and Mill Location

Mill No.	Company Name	Town	State	Bleached Kraft Pulp (tpd)			Unbleached Kraft Pulp (tpd)			Total Paper Quantity (tpd)
				Total	Softwood	Hardwood	Total	Softwood	Hardwood	
1	Alaska Pulp Co.	Sitka	AK	—	—	—	—	—	—	—
2	Appleton Papers, Inc.	Roaring Springs	PA	200	[a]	[a]	—	—	—	210
3	Badger Paper Mills, Inc.	Peshigo	WI	—	—	—	—	—	—	210
4	Boise Cascade Corp.	Jackson	AL	600	[a]	[a]	—	—	—	240
5	Boise Cascade Corp.	Deridder	LA	250	250	—	1,050	1,050	—	2,300
6	Boise Cascade Corp.	Rumford	ME	610	260	370	—	—	—	1,475
7	Boise Cascade Corp.	International Falls	MN	400	[a]	[a]	—	—	—	570
8	Boise Cascade Corp.	St. Helens	OR	—	—	—	—	955	—	700
9	Boise Cascade Corp.	Wallula	WA	—	—	—	803	803	—	[a]
10	Bowater Corp.	Catawba	SC	1,350	1,350	—	—	—	—	920
11	Bowater Corp.	Calhoun	TN	700	700	—	—	—	—	2,150
12	Brunswick Pulp and Paper	Brunswick	GA	1,800	1,800	—	—	—	—	530
13	Buckeye Cellulose	Perry	FL	1,100	1,100	—	—	—	—	—
14	Buckeye Cellulose	Oglethorpe	GA	750	[a]	[a]	—	—	—	—
15	Champion International	Courtland	AL	1,300	550	750	—	—	—	1,550
16	Champion International	Cantonment	FL	1,400	[a]	[a]	—	—	—	1,025
17	Champion International	Quinnesec	MI	825	—	825	—	—	—	—
18	Champion International	Canton	NC	1,440	875	565	—	—	—	1,675
19	Champion International	Houston	TX	500	500	—	—	—	—	1,310
20	Champion International	Lufkin	TX	300	[a]	[a]	100	—	—	1,262
21	Chesapeake Corp.	West Point	VA	1,900	1,450	450	—	—	—	1,300
22	Container Corp. of America	Brewton	AL	450	450	—	650	650	—	1,200
23	Federal Paper Board Co.	Augusta	GA	1,300	250	1,050	—	—	—	1,370
24	Federal Paper Board Co.	Riegelwood	NC	2,260	[a]	[a]	—	—	—	910
25	Finch Pruyn & Co., Inc.	Glenn Falls	NY	—	—	—	—	—	—	575
26	Flambeau Papers (div. Pentair)	Park Falls	WI	—	—	—	—	—	—	375
27	Gaylord Container Corp.	Antioch	CA	—	—	—	700	[a]	[a]	1,500
28	Georgia-Pacific Corp.	Crossett	AR	1,500	600	900	—	—	—	1,338
29	Georgia-Pacific Corp.	Palatka	FL	450	[a]	[a]	750	[a]	[a]	1,185
30	Georgia-Pacific Corp.	Woodland	ME	840	—	840	—	—	—	313
31	Georgia-Pacific Corp.	Bellingham	WA	—	—	—	—	—	—	250
32	Gilman Paper Co.	St. Marys	GA	—	900	—	—	300	—	1,200
33	Gulf States Paper Corp.	Demopolis	AL	500	[a]	[a]	—	—	—	625
34	Hammermill Paper Co.	Selma	AL	1,375	[a]	[a]	—	—	—	525
35	Hammermill Paper Co.	Erie	PA	—	—	—	—	—	—	550
36	International Paper Co.	Mobile	AL	345	[a]	[a]	690	[a]	[a]	[a]
37	International Paper Co.	Pine Bluff	AR	1,112	[a]	[a]	—	—	—	[a]
38	International Paper Co.	Bastrop	LA	—	—	—	—	—	—	606

Table 2.A

(cont.)

Outputs of 99 Pulp Mills From EPA's Study Group
of 104 Bleached Pulp Mills, by Firm and Mill Location

Mill No.	Company Name	Town	State	Bleached Kraft Pulp (tpd)			Unbleached Kraft Pulp (tpd)			Total Paper Quantity (tpd)
				Total	Softwood	Hardwood	Total	Softwood	Hardwood	
39	International Paper Co.	Jay	ME	1,200	[a]	[a]	—	—	—	1,350
40	International Paper Co.	Natchez	MS	600	—	600	—	—	—	—
41	International Paper Co.	Moss Point	MS	661	[a]	[a]	—	—	—	760
42	International Paper Co.	Ticonderoga	NY	530	[a]	[a]	—	—	—	690
43	International Paper Co.	Georgetown	SC	[a]	[a]	—	—	—	—	[a]
44	International Paper Co.	Texarkana	TX	1,215	[a]	[a]	—	—	—	[a]
45	ITT-Rayonier, Inc.	Fernandina Beach	FL	—	—	—	—	—	—	—
46	ITT-Rayonier, Inc.	Jesup	GA	1,725	1,725	—	—	—	—	—
47	ITT-Rayonier, Inc.	Hoquiam	WA	—	—	—	—	—	—	—
48	ITT-Rayonier, Inc.	Port Angeles	WA	—	—	—	—	—	—	—
49	James River Corp.	St. Francisville	LA	675	[a]	[a]	—	—	—	975
50	James River Corp.	Old Town	ME	600	[a]	[a]	—	—	—	[a]
51	James River Corp.	Berlin	NH	700	[a]	[a]	100	[a]	[a]	—
52	James River Corp.	Clatskanie	OR	836	[a]	[a]	—	—	—	910
53	James River Corp.	Camas	WA	1,000	[a]	[a]	—	—	—	1,450
54	James River Corp.	Green Bay	WI	—	—	—	—	—	—	470
55	Ketchikan Pulp & Paper Co.	Ketchikan	AK	—	—	—	—	—	—	—
56	Kimberly-Clark Corp.	Coosa Pines	AL	1,200	[a]	[a]	—	—	—	1,200
57	Leaf River Forest Products	New Augusta	MS	1,484	[a]	[a]	—	—	—	—
58	Lincoln Pulp and Paper	Lincoln	ME	340	—	340	—	—	—	270
59	Longview Fiber Co.	Longview	WA	230	[a]	[a]	2,400	[a]	[a]	2,600
60	Louisiana Pacific Corp.	Samoa	CA	600	600	—	—	—	—	—
61	Mead Corporation	Escanaba	MI	600	200	400	—	—	—	1,480
62	Mead Corporation	Chillicothe	OH	870	[a]	[a]	—	—	—	1,171
63	Mead Corporation	Kingsport	TN	250	—	250	—	—	—	550
64	Nekoosa Papers, Inc.	Ashdown	AR	1,350	750	600	—	—	—	—
65	Nekoosa Papers, Inc.	Port Edwards	WI	—	—	—	—	—	—	440
66	Nekoosa Papers, Inc.	Nekoosa	WI	350	[a]	[a]	—	—	—	575
67	Penntech Papers, Inc.	Johnsonburg	PA	215	—	215	—	—	—	400
68	Pope & Talbot, Inc.	Halsey	OR	520	520	—	—	—	—	—
69	Pottlatch Corp.	McGhee	AR	450	[a]	[a]	—	—	—	500
70	Pottlatch Corp.	Lewiston	ID	1,300	[a]	[a]	—	—	—	925
71	Pottlatch Corp.	Cloquet	MN	520	100	420	—	—	—	550
72	Proctor & Gamble Co.	Mahoopany	PA	—	—	—	—	—	—	[a]
73	P.H. Glatfelter Co.	Spring Grove	PA	560	[a]	[a]	—	—	—	800
74	Scott Paper Co.	Mobile	AL	—	—	—	—	—	—	2,450
75	Scott Paper Co.	Hinckley	ME	900	[a]	[a]	—	—	—	600
76	Scott Paper Co.	Westbrook	ME	300	160	140	—	—	—	[a]

Table 2.A

(cont.)

Outputs of 99 Pulp Mills From EPA's Study Group
of 104 Bleached Pulp Mills, by Firm and Mill Location

Mill No.	Company Name	Town	State	Bleached Kraft Pulp (tpd)			Unbleached Kraft Pulp (tpd)			Total Paper Quantity* (tpd)
				Total	Softwood	Hardwood	Total	Softwood	Hardwood	
77	Scott Paper Co.	Muskegon	MI	250	125	125	—	—	—	[a]
78	Scott Paper Co.	Everett	WA	—	—	—	—	—	—	[a]
79	Simpson Paper Co.	Anderson	CA	250	250	—	—	—	—	420
80	Simpson Paper Co.	Fairhaven	CA	580	127	453	—	—	—	—
81	Simpson Paper Co.	Pasadena	TX	725	400	325	—	—	—	760
82	Simpson Paper Co.	Tacoma	WA	[a]	[a]	[a]	1,200	1,200	—	870
83	Stone Container Corp.	Snowflake	AZ	150	150	—	550	550	—	1,250
84	Stone Container Corp.	Panama City	FL	725	—	725	800	800	—	800
85	Stone Container Corp.	Missoula	MT	—	—	—	1,910	1,910	—	1,910
86	St. Joe Paper Co.	Port St. Joe	FL	500	—	500	1,200	1,200	—	1,400
87	Union Camp Corp.	Eastover	SC	600	[a]	[a]	—	—	—	600
88	Union Camp Corp.	Franklin	VA	1,950	[a]	[a]	—	—	—	1,900
89	Wausau Pulp and Paper	Brokaw	WI	—	—	—	—	—	—	480
90	Westvaco Corp.	Wickliffe	KY	930	[a]	[a]	—	—	—	600
91	Westvaco Corp.	Luke	MD	913	[a]	[a]	—	—	—	1,174
92	Westvaco Corp.	Covington	VA	1,400	[a]	[a]	—	—	—	2,000
93	Weyerhaeuser Co.	Plymouth	NC	955	520	435	—	450	—	[a]
94	Weyerhaeuser Co.	New Bern	NC	811	[a]	[a]	—	—	—	—
95	Weyerhaeuser Co.	Longview	WA	750	750	—	—	—	—	855
96	Weyerhaeuser Co.	Everett	WA	385	385	—	—	—	—	—
97	Weyerhaeuser Co.	Cosmopolis	WA	—	—	—	—	—	—	—
98	Weyerhaeuser Co.	Rothchild	WI	—	—	—	—	—	—	350
99	Willamette Industries	Hawesville	KY	700	—	700	—	—	—	—

— None reported.

[a] Some production indicated, but quantity not separately reported.

Source: Lockwood-Post's Directory of the Pulp, Paper, and Allied Trades
(1990), as coded by ERG.

APPENDIX 2.B

**COMPREHENSIVE LISTING OF MILL OUTPUTS
FOR ALL PAPER AND PAPERBOARD GRADES**

**99 OF 104 MILLS IN EPA'S
BLEACHED PULP MILL STUDY GROUP**

Quantities and Grades of Paper and Board Produced at 99 of 104 Bleached Pulp Mills in EPA Study Group	1	2	3	4	5
	Alaska Pulp Co.	Appleton Papers, Inc.	Badger Paper Mills, Inc.	Bolae Cascade Corp.	Bolae Cascade Corp.
	Sitka Alaska	Roaring Springs Pennsylvania	Peshtigo Wisconsin	Jackson Alabama	Deridder Louisiana
TOTAL PAPER VOLUME (tons per day) [a]	[b]	210	210	240	2,300
Paper, all grades					1,100
Newsprint					
Printing and writing papers					
Uncoated groundwood					
Publishing and printing paper					
Converting paper					
Coated papers					
Uncoated free sheet					
Bond and writing			X	X	
Form bond					
Ledger					
Mimeograph			X		
Duplicating			X	X	
Manifold					
Paperette and wedding					
Carbonless					
Opaque circular			X		
Cover and text papers				X	
M.F., E.F., and super calendered					
Offset					
White wove envelope				X	
Tablet				X	
Kraft envelope - brown					
Kraft envelope - bleached					
Other			X	X	
Thin papers		210			
Cotton fiber papers					
Bond and writing					
Other Business					
Technical and other					
Bleached Bristol					
Tabulating index					
File folder					
Index Bristol					
Printing Bristol					
Postcard					
Coated Bristol					
Packaging, industrial and other					
Packaging, industrial and other, unbl. kraft					800
Wrapping, unbl. kraft					
Bag and sack (exc. shipping), unbl. kraft					
Shipping sack, unbl. kraft					
Other converting (pkg'g & indus), unbl. kraft					
Packaging, industrial and other, bl. kraft					
Wrapping, bl.					
Bag and sack (exc. shipping), bl.					
Shipping sack, bl.					
Other converting (pkg'g & indus), bl.			X		
Special industrial papers					
Tissue					
Sanitary tissue					
Toilet tissue					
Facial tissue stock					
Napkin stock					
Towelling					
Wiper stock					
Other sanitary tissue					
Other tissue					
Paperboard, all grades					
Containerboard					
Linerboard					
Linerboard, unbl. kraft					800
Linerboard, bl. kraft					
Linerboard, recycled					
Corrugating material					
Corrugating material, unbl. kraft					
Corrugating material, semi-chemical					
Corrugating material, recycled					
Chip and filler board, recycled					
Boxboard					
Folding boxboard					
Folding boxboard, bl. kraft					
Folding boxboard, recycled					
Setup boxboard, recycled					
Milk carton boxboard, bl. kraft					
Heavyweight food containers, bl. kraft					
Plate, dish & tray, bl. kraft					
Other boxboard, bl. kraft					
Other boxboard, recycled					
Other paperboard					

X - Quantity not reported.

[a][b][c] See notes at end of table.

Source: Lockwood Post's Directory of the Pulp, Paper and Allied Trades (1990), as coded by ERG.

Quantities and Grades of Paper and Board Produced at 99 of 104 Bleached Pulp Mills in EPA Study Group	6 Boise Cascade Corp.	7 Boise Cascade Corp.	8 Boise Cascade Corp.	9 Boise Cascade Corp.	10 Bowater Corp.
	Rumford Maine	International Falls Minnesota	St. Helens Oregon	Wallula Washington	Catawba South Carolina
TOTAL PAPER VOLUME	1,475	570	700	495	620
Paper, all grades					
Newsprint					
Printing and writing papers			X		
Uncoated groundwood					
Publishing and printing paper	X				
Converting paper					
Coated papers	X				620
Uncoated free sheet		X			
Bond and writing					
Form bond	X		X		
Ledger					
Mimeograph					
Duplicating					
Manifold					
Papeterie and wedding					
Carbonless					
Opaque circular					
Cover and text papers					
M.F., E.F., and super calendered					
Offset					
White wove envelope	X		X		
Tablet	X				
Kraft envelope - brown					
Kraft envelope - bleached					
Other				590	
Thin papers					
Cotton fiber papers					
Bond and writing					
Other Business					
Technical and other					
Bleached Bristol					
Tabulating index					
File folder					
Index Bristol					
Printing Bristol					
Postcard					
Coated Bristol					
Packaging, industrial and other					
Packaging, industrial and other, unbl. kraft					
Wrapping, unbl. kraft					
Bag and sack (exc. shipping), unbl. kraft					
Shipping sack, unbl. kraft					
Other converting (pkg'g & indus), unbl. kraft			X		
Packaging, industrial and other, bl. kraft					
Wrapping, bl.					
Bag and sack (exc. shipping), bl.					
Shipping sack, bl.					
Other converting (pkg'g & indus), bl.					
Special industrial papers					
Tissue					
Sanitary tissue			X		
Toilet tissue					
Facial tissue stock					
Napkin stock					
Toweling					
Wiper stock					
Other sanitary tissue					
Other tissue					
Paperboard, all grades					
Containerboard					
linerboard					
linerboard, unbl. kraft					
linerboard, bl. kraft					
linerboard, recycled					
Corrugating material					306
Corrugating material, unbl. kraft					
Corrugating material, semi-chemical					
Corrugating material, recycled					
Chip and filler board, recycled					
Boxboard					
Folding boxboard					
Folding boxboard, bl. kraft					
Folding boxboard, recycled					
Setup boxboard, recycled					
Milk carton boxboard, bl. kraft					
Heavyweight food containers, bl. kraft					
Plate, dish & tray, bl. kraft					
Other boxboard, bl. kraft					
Other boxboard, recycled					
Other paperboard					

X - Quantity not reported.

(a)(b)(c) See notes at end of table.

Source: Lockwood Post's Directory of the Pulp, Paper and Allied Trades (1990), as coded by ERG.

Quantities and Grades of Paper and Board Produced at 99 of 104 Bleached Pulp Mills in EPA Study Group	11 Bowater Corp.	12 Brunswick Pulp and Paper	13 Buckeye Cellulose	14 Buckeye Cellulose	15 Champion International
	Calhoun Tennessee	Brunswick Georgia	Perry Florida	Oglethorpe Georgia	Courtland Alabama
TOTAL PAPER VOLUME	2,150	530	[b]	[b]	1,550
Paper, all grades					
Newsprint	X				
Printing and writing papers					
Uncoated groundwood					
Publishing and printing paper					
Converting paper					
Coated papers					
Uncoated free sheet					
Bond and writing					
Form bond					
Ledger					X
Mimeograph					X
Duplicating					
Manifold					
Paperette and wedding					
Carbonless					
Opaque circular					
Cover and text papers					
M.F., E.F., and super calendered					
Offset					X
White wove envelope					X
Tabulat					
Kraft envelope - brown					
Kraft envelope - bleached					
Other					X
Thin papers					
Cotton fiber papers					
Bond and writing					
Other Business					
Technical and other					
Bleached Bristol					
Tabulating Index					
File folder		X			
Index Bristol					
Printing Bristol					
Postcard					
Coated Bristol					
Packaging, industrial and other					
Packaging, industrial and other, unbl. kraft					
Wrapping, unbl. kraft					
Bag and sack (exc. shipping), unbl. kraft					
Shipping sack, unbl. kraft					
Other converting (pkg'g & indust), unbl. kraft					
Packaging, industrial and other, bl. kraft					
Wrapping, bl.					
Bag and sack (exc. shipping), bl.					
Shipping sack, bl.					
Other converting (pkg'g & indust), bl.					
Special industrial papers					
Tissue					
Sanitary tissue					
Toilet tissue					
Facial tissue stock					
Napkin stock					
Towelling					
Wiper stock					
Other sanitary tissue					
Other tissue					
Paperboard, all grades					
Containerboard					
Linerboard					
Linerboard, unbl. kraft					
Linerboard, bl. kraft					
Linerboard, recycled					
Corrugating material					
Corrugating material, unbl. kraft					
Corrugating material, semi-chemical					
Corrugating material, recycled					
Chip and filler board, recycled					
Boxboard					
Folding boxboard					
Folding boxboard, bl. kraft		X			
Folding boxboard, recycled		X			
Setup boxboard, recycled					
Milk carton boxboard, bl. kraft					
Heavyweight food containers, bl. kraft					
Plate, dish & tray, bl. kraft		X			
Other boxboard, bl. kraft					
Other boxboard, recycled					
Other paperboard					

X - Quantity not reported.

[a][b][c] See notes at end of table.

Source: Lockwood Post's Directory of the Pulp, Paper and Allied Trades (1990), as coded by ERG.

Quantities and Grades of Paper and Board Produced at 99 of 104 Bleached Pulp Mills in EPA Study Group	16 Champion International	17 Champion International	18 Champion International	19 Champion International	20 Champion International
	Cantonment Florida	Guinness Michigan	Canton North Carolina	Houston Texas	Lufkin Texas
TOTAL PAPER VOLUME	1,025	[b]	1,675	1,310	1,262
Paper, all grades					
Newsprint				1,310	872
Printing and writing papers					
Uncoated groundwood					
Publishing and printing paper					290
Converting paper					
Coated papers					
Uncoated free sheet					
Bond and writing			162		
Form bond					
Ledger					
Mimeograph			162		
Duplicating					
Manifold					
Paperette and wedding					
Carbonless					
Opaque circular					
Cover and text papers					
M.F., E.F., and super calendered					
Offset	X		162		
White wove envelope			161		
Tablet			161		
Kraft envelope - brown					
Kraft envelope - bleached					
Other	X				
Thin papers					
Cotton fiber papers					
Bond and writing					
Other Business					
Technical and other					
Bleached Bristol					
Tabulating index					
File folder					
Index Bristol					
Printing Bristol					
Postcard					
Coated Bristol					
Packaging, industrial and other					
Packaging, industrial and other, unbl. kraft					
Wrapping, unbl. kraft					
Bag and sack (exc. shipping), unbl. kraft					
Shipping sack, unbl. kraft					
Other converting (pkg'g & indus), unbl. kraft					
Packaging, industrial and other, bl. kraft					
Wrapping, bl.					
Bag and sack (exc. shipping), bl.					
Shipping sack, bl.	X				
Other converting (pkg'g & indus), bl.					
Special industrial papers					
Tissue					
Sanitary tissue					
Toilet tissue					
Facial tissue stock					
Napkin stock					
Towelstock					
Wiper stock					
Other sanitary tissue					
Other tissue					
Paperboard, all grades					
Containerboard					
Linerboard					
Linerboard, unbl. kraft					
Linerboard, bl. kraft					
Linerboard, recycled					
Corrugating material					
Corrugating material, unbl. kraft					
Corrugating material, semi-chemical					
Corrugating material, recycled					
Chip and filler board, recycled					
Boxboard					
Folding boxboard					
Folding boxboard, bl. kraft					
Folding boxboard, recycled					
Setup boxboard, recycled					
Milk carton boxboard, bl. kraft			352		
Heavyweight food containers, bl. kraft			353		
Plate, dish & tray, bl. kraft	X				
Other boxboard, bl. kraft					
Other boxboard, recycled					
Other paperboard					

X - Quantity not reported.

[a][b][c] See notes at end of table.

Source: Lockwood Post's Directory of the Pulp, Paper and Allied Trades (1990), as coded by ERG.

Quantities and Grades of Paper and Board Produced at 99 of 104 Bleached Pulp Mills in EPA Study Group	21 Chesapeake Corp.	22 Container Corp. of America	23 Federal Paper Board Co.	24 Federal Paper Board Co.	25 Finch Pruyn & Co., Inc.
	West Point Virginia	Brewton Alabama	Augusta Georgia	Riegelwood North Carolina	Glenns Falls New York
TOTAL PAPER VOLUME	1,300	1,200	1,370	910	678
Paper, all grades					
Newsprint					
Printing and writing papers					
Uncoated groundwood					
Publishing and printing paper					
Converting paper					
Coated papers				X	X
Uncoated free sheet					
Bond and writing					X
Form bond					
Ledger					X
Mimeograph					
Duplicating					X
Manifold					
Papeterie and wedding					
Carbonless					
Opaque circular					
Cover and text papers					X
M.F., E.F., and super calendered					
Offset					
White wove envelope					
Tablet					
Kraft envelope - brown					
Kraft envelope - bleached					
Other					
Thin papers					
Cotton fiber papers					
Bond and writing					
Other Business					
Technical and other					
Bleached Bristol			X		
Tabulating Index					
File folder					
Index Bristol					
Printing Bristol					
Postcard					
Coated Bristol				X	
Packaging, industrial and other					
Packaging, industrial and other, unbl. kraft					
Wrapping, unbl. kraft					
Bag and sack (exc. shipping), unbl. kraft	178				
Shipping sack, unbl. kraft	178				
Other converting (pkg'g & indus), unbl. kraft					
Packaging, industrial and other, bl. kraft					
Wrapping, bl.					
Bag and sack (exc. shipping), bl.					
Shipping sack, bl.					
Other converting (pkg'g & indus), bl.					
Special industrial papers					
Tissue					
Sanitary tissue					
Toilet tissue					
Facial tissue stock					
Napkin stock					
Toweling					
Wiper stock					
Other sanitary tissue					
Other tissue					
Paperboard, all grades					
Containerboard					
Linerboard					
Linerboard, unbl. kraft	498	X			
Linerboard, bl. kraft				X	
Linerboard, recycled					
Corrugating material					
Corrugating material, unbl. kraft	196				
Corrugating material, semi-chemical					
Corrugating material, recycled					
Chip and filler board, recycled					
Boxboard					
Folding boxboard					
Folding boxboard, bl. kraft			X	X	
Folding boxboard, recycled					
Setup boxboard, recycled					
Milk carton boxboard, bl. kraft		X		X	
Heavyweight food containers, bl. kraft				X	
Plate, dish & tray, bl. kraft			X		
Other boxboard, bl. kraft					
Other boxboard, recycled					
Other paperboard					

X - Quantity not reported.

[a][b][c] See notes at end of table.

Source: Lockwood Fast's Directory of the Pulp, Paper and Allied Trades (1990), as coded by ERG.

Quantities and Grades of Paper and Board Produced at 99 of 104 Bleached Pulp Mills in EPA Study Group	31 Georgia-Pacific Corp.	32 Gillman Paper Co.	33 Gulf States Paper Corp.	34 Hammermill Paper Co.	35 Hammermill Paper Co.
	Bellingham Washington	St. Marys Georgia	Demopolis Alabama	Selma Alabama	Erie Pennsylvania
TOTAL PAPER VOLUME	250	1,200	628	525	650
Paper, all grades					
Newsprint					
Printing and writing papers					
Uncoated groundwood					
Publishing and printing paper					
Converting paper					
Coated papers					
Uncoated free sheet				X	
Bond and writing					X
Form bond					
Ledger					X
Mimeograph					
Duplicating					X
Manifold					
Papeterie and wedding					
Carbonless					
Opaque circular					X
Cover and text papers					
M.F., E.F., and super calendered					
Offset					X
White wove envelope					X
Tablet					
Kraft envelope - brown					
Kraft envelope - bleached					
Other					X
Thin papers					
Cotton fiber papers					
Bond and writing					
Other Business					
Technical and other					
Bleached Bristol					
Tabulating index					
File folder					
Index Bristol					X
Printing Bristol					
Postcard					
Coated Bristol					
Packaging, industrial and other					
Packaging, industrial and other, unbl. kraft					
Wrapping, unbl. kraft					
Bag and sack (exc. shipping), unbl. kraft		175			
Shipping sack, unbl. kraft					
Other converting (pkg'g & indus), unbl. kraft		175			
Packaging, industrial and other, bl. kraft					
Wrapping, bl.					
Bag and sack (exc. shipping), bl.		175			
Shipping sack, bl.					
Other converting (pkg'g & indus), bl.		175			
Special industrial papers					
Tissue					
Sanitary tissue					
Toilet tissue	X				
Facial tissue stock	X				
Napkin stock	X				
Towelling	X				
Wiper stock					
Other sanitary tissue					
Other tissue					
Paperboard, all grades					
Containerboard					
Linerboard					
Linerboard, unbl. kraft					
Linerboard, bl. kraft					
Linerboard, recycled					
Corrugating material					
Corrugating material, unbl. kraft					
Corrugating material, semi-chemical					
Corrugating material, recycled					
Chip and filler board, recycled					
Boxboard					
Folding boxboard					
Folding boxboard, bl. kraft			X		
Folding boxboard, recycled					
Setup boxboard, recycled					
Milk carton boxboard, bl. kraft			X		
Heavyweight food containers, bl. kraft		600	X		
Plate, dish & tray, bl. kraft					
Other boxboard, bl. kraft					
Other boxboard, recycled					
Other paperboard					

X - Quantity not reported.

[a][b][c] See notes at end of table.

Source: Lockwood Post's Directory of the Pulp, Paper and Allied Trades (1990), as coded by ERG.

Quantities and Grades of Paper and Board Produced at 99 of 104 Bleached Pulp Mills in EPA Study Group	36 ITT-Rayonier, Inc.	37 ITT-Rayonier, Inc.	38 ITT-Rayonier, Inc.	39 ITT-Rayonier, Inc.	40 International Paper Co.
	Fernandina Beach Florida	Jesup Georgia	Hoquiam Washington	Port Angeles Washington	Mobile Alabama
TOTAL PAPER VOLUME	[b]	[b]	[b]	[b]	[a]
Paper, all grades					
Newspaper					
Printing and writing papers					
Uncoated groundwood					
Publishing and printing paper					
Converting paper					
Coated papers					
Uncoated free sheet					X
Bond and writing					
Form bond					
Ledger					
Mimeograph					
Duplicating					
Manifold					
Papeterie and wedding					
Carbonless					
Opaque circular					
Cover and text papers					
M.F., E.F., and super calendered					
Offset					
White wove envelope					
Tablet					
Kraft envelope - brown					
Kraft envelope - bleached					
Other					
Thin papers					
Cotton fiber papers					
Bond and writing					
Other Business					
Technical and other					
Bleached Bristols					
Tabulating index					
File folder					
Index Bristol					
Printing Bristol					
Postcard					
Coated Bristol					
Packaging, industrial and other					
Packaging, industrial and other, unbl. kraft					
Wrapping, unbl. kraft					X
Bag and sack (exc. shipping), unbl. kraft					
Shipping sack, unbl. kraft					
Other converting (pkg'g & indus), unbl. kraft					X
Packaging, industrial and other, bl. kraft					
Wrapping, bl.					X
Bag and sack (exc. shipping), bl.					
Shipping sack, bl.					
Other converting (pkg'g & indus), bl.					
Special industrial papers					
Tissue					
Sanitary tissue					
Toilet tissue					
Facial tissue stock					
Napkin stock					
Towelling					
Wiper stock					
Other sanitary tissue					
Other tissue					
Paperboard, all grades					
Containerboard					
Linerboard					
Linerboard, unbl. kraft					
Linerboard, bl. kraft					
Linerboard, recycled					
Corrugating material					
Corrugating material, unbl. kraft					
Corrugating material, semi-chemical					
Corrugating material, recycled					
Chip and filler board, recycled					
Boxboard					
Folding boxboard					
Folding boxboard, bl. kraft					
Folding boxboard, recycled					
Setup boxboard, recycled					
Milk carton boxboard, bl. kraft					
Heavyweight food containers, bl. kraft					
Plate, dish & tray, bl. kraft					
Other boxboard, bl. kraft					
Other boxboard, recycled					
Other paperboard					

X - Quantity not reported.

[a][b][c] See notes at end of table.

Source: Lockwood Post's Directory of the Pulp, Paper and Allied Trades (1990), as coded by ERG.

Quantities and Grades of Paper and Board Produced at 99 of 104 Bleached Pulp Mills in EPA Study Group	41 International Paper Co.	42 International Paper Co.	43 International Paper Co.	44 International Paper Co.	45 International Paper Co.
	Pine Bluff Arkansas	Bastrop Louisiana	Jay Maine	Moss Point Mississippi	Natchez Mississippi
TOTAL PAPER VOLUME	[a]	606	1,350	780	[b]
Paper, all grades					
Newsprint					
Printing and writing papers					
Uncoated groundwood					
Publishing and printing paper					
Converting paper					
Coated papers	X		X		
Uncoated free sheet					
Bond and writing			X		
Form bond					
Ledger					
Mimeograph					
Duplicating					
Manifold					
Papeterie and wedding					
Carbonless					
Opaque circular					
Cover and text papers					
M.F., E.F., and super calendered					
Offset					
White wove envelope					
Tablet					
Kraft envelope - brown					
Kraft envelope - bleached					
Other					
Thin papers			X		
Cotton fiber papers					
Bond and writing					
Other Business					
Technical and other					
Bleached Bristol				X	
Tabulating index					
File folder					
Index Bristol					
Printing Bristol					
Postcard					
Coated Bristol					
Packaging, industrial and other					
Packaging, industrial and other, unbl. kraft					
Wrapping, unbl. kraft					
Bag and sack (exc. shipping), unbl. kraft					
Shipping sack, unbl. kraft					
Other converting (pkg'g & indus), unbl. kraft					
Packaging, industrial and other, bl. kraft					
Wrapping, bl.				X	
Bag and sack (exc. shipping), bl.					
Shipping sack, bl.					
Other converting (pkg'g & indus), bl.				X	
Special industrial papers					
Tissue					
Sanitary tissue					
Toilet tissue					
Facial tissue stock					
Napkin stock					
Toweling					
Wiper stock					
Other sanitary tissue					
Other tissue					
Paperboard, all grades					
Containerboard					
Linerboard					
Linerboard, unbl. kraft					
Linerboard, bl. kraft				X	
Linerboard, recycled					
Corrugating material					
Corrugating material, unbl. kraft					
Corrugating material, semi-chemical		X			
Corrugating material, recycled					
Chip and fiber board, recycled					
Boxboard					
Folding boxboard					
Folding boxboard, bl. kraft	X				
Folding boxboard, recycled					
Setup boxboard, recycled					
Milk carton boxboard, bl. kraft					
Heavyweight food containers, bl. kraft					
Plate, dish & tray, bl. kraft					
Other boxboard, bl. kraft					
Other boxboard, recycled					
Other paperboard					

X - Quantity not reported.

[a][b][c] See notes at end of table.

Source: Lockwood Post's Directory of the Pulp, Paper and Allied Trades (1990), as coded by ERG.

Quantities and Grades of Paper and Board Produced at 99 of 104 Bleached Pulp Mills in EPA Study Group	26 Flembeau Papers (div. Pentair)	27 Gaylord Container Corp.	28 Georgia-Pacific Corp.	29 Georgia-Pacific Corp.	30 Georgia-Pacific Corp.
	Park Falls Wisconsin	Antioch California	Crossett Arkansas	Palatka Florida	Woodland Maine
TOTAL PAPER VOLUME	375	1,500	1,336	1,196	313
Paper, all grades					
Newsprint					
Printing and writing papers					
Uncoated groundwood					
Publishing and printing paper					X
Converting paper					
Coated papers					
Uncoated free sheet			460		
Bond and writing	X				
Form bond					
Ledger	X				
Mimeograph					
Duplicating	X				
Manifold					
Paperene and wedding					
Carbonless					
Opaque circular	X				
Cover and text papers					
M.F., E.F., and super calendered					
Offset					X
White wove envelope					
Tablet					
Kraft envelope - brown					
Kraft envelope - bleached					
Other					
Thin papers					
Cotton fiber papers					
Bond and writing					
Other Business					
Technical and other					
Bleached Bristols					
Tabulating index					
File folder					
Index Bristol					
Printing Bristol					
Postcard					
Coated Bristol					
Packaging, industrial and other					
Packaging, industrial and other, unbl. kraft					
Wrapping, unbl. kraft					
Bag and sack (exc. shipping), unbl. kraft				340	
Shipping sack, unbl. kraft					
Other converting (pkg'g & indus), unbl. kraft				340	
Packaging, industrial and other, bl. kraft					
Wrapping, bl.					
Bag and sack (exc. shipping), bl.					
Shipping sack, bl.					
Other converting (pkg'g & indus), bl.					
Special industrial papers					
Tissue					
Sanitary tissue					
Toilet tissue			110	128	
Facial tissue stock			110	129	
Napkin stock			110	129	
Towelstock			110	340	
Wiper stock					
Other sanitary tissue					
Other tissue					
Paperboard, all grades					
Containerboard					
Linerboard					
Linerboard, unbl. kraft		X			
Linerboard, bl. kraft		X			
Linerboard, recycled					
Corrugating material					
Corrugating material, unbl. kraft		X			
Corrugating material, semi-chemical					
Corrugating material, recycled					
Chip and filler board, recycled					
Boxboard					
Folding boxboard					
Folding boxboard, bl. kraft					
Folding boxboard, recycled					
Setup boxboard, recycled					
Milk carton boxboard, bl. kraft			145		
Heavyweight food containers, bl. kraft			145		
Plate, dish & tray, bl. kraft			145		
Other boxboard, bl. kraft					
Other boxboard, recycled					
Other paperboard					

X - Quantity not reported.

[a][b][c] See notes at end of table.

Source: Lockwood Post's Directory of the Pulp, Paper and Allied Trades (1990), as coded by ERG.

Quantities and Grades of Paper and Board Produced at 99 of 104 Bleached Pulp Mills in EPA Study Group	46 International Paper Co.	47 International Paper Co.	48 International Paper Co.	49 James River Corp.	50 James River Corp.
	Ticonderoga New York	Georgetown South Carolina	Texarkana Texas	St. Francisville Louisiana	Old Town Maine
TOTAL PAPER VOLUME	690	[a]	[a]	878	[a]
Paper, all grades					
Newsprint					
Printing and writing papers					
Uncoated groundwood					
Publishing and printing paper					
Converting paper					
Coated papers				700	
Uncoated free sheet					
Bond and writing					
Form bond		X			
Ledger					
Mimeograph					
Duplicating					
Manifold					
Papeterie and wedding					
Carbonless					
Opaque circular					
Cover and text papers	X				
M.F., E.F., and super calendered					
Offset	X	X			
White wove envelope	X	X			
Tablet	X	X			
Kraft envelope - brown					
Kraft envelope - bleached					
Other					
Thin papers					
Cotton fiber papers					
Bond and writing					
Other Business					
Technical and other					
Bleached Bristol					
Tabulating index					
File folder		X			
Index Bristol					
Printing Bristol					
Postcard					
Coated Bristol					
Packaging, industrial and other					
Packaging, industrial and other, unbl. kraft					
Wrapping, unbl. kraft					
Bag and sack (exc. shipping), unbl. kraft					
Shipping sack, unbl. kraft					
Other converting (pkg'g & indus), unbl. kraft					
Packaging, industrial and other, bl. kraft					
Wrapping, bl.					
Bag and sack (exc. shipping), bl.					
Shipping sack, bl.					
Other converting (pkg'g & indus), bl.				276	
Special industrial papers					
Tissue					
Sanitary tissue					
Toilet tissue					X
Facial tissue stock					X
Napkin stock					X
Towelings					X
Wiper stock					
Other sanitary tissue					
Other tissue					
Paperboard, all grades					
Containerboard					
Linerboard					
Linerboard, unbl. kraft					
Linerboard, bl. kraft			X		
Linerboard, recycled					
Corrugating material					
Corrugating material, unbl. kraft					
Corrugating material, semi-chemical					
Corrugating material, recycled					
Chip and filler board, recycled					
Boxboard					
Folding boxboard					
Folding boxboard, bl. kraft					
Folding boxboard, recycled					
Setup boxboard, recycled					
Milk carton boxboard, bl. kraft					
Heavyweight food containers, bl. kraft					
Plate, dish & tray, bl. kraft		X			
Other boxboard, bl. kraft					
Other boxboard, recycled					
Other paperboard					

X - Quantity not reported.

[a][b][c] See notes at end of table.

Source: Lockwood Post's Directory of the Pulp, Paper and Allied Trades (1990), as coded by ERG.

Quantities and Grades of Paper and Board Produced at 99 of 104 Bleached Pulp Mills in EPA Study Group	51 James River Corp.	52 James River Corp.	53 James River Corp.	54 James River Corp.	55 Ketchikan Pulp & Paper Co.
	Berlin New Hampshire	Cleatonie Oregon	Cameo Washington	Green Bay Wisconsin	Ketchikan Alaska
TOTAL PAPER VOLUME	[b]	910	1,460	470	[b]
Paper, all grades					
Newsprint		175			
Printing and writing papers					
Uncoated groundwood					
Publishing and printing paper					
Converting paper		176			
Coated papers					
Uncoated free sheet		300			
Bond and writing					
Form bond			X		
Lodger					
Mimeograph					
Duplicating					
Manifold					
Papeterie and wedding					
Carbonless					
Opaque circular					
Cover and text papers					
M.F., E.F., and super calendered					
Offset					
White wove envelope			X		
Tablet			X		
Kraft envelope - brown					
Kraft envelope - bleached					
Other					
Thin papers					
Cotton fiber papers					
Bond and writing					
Other Business					
Technical and other					
Bleached Bristol					
Tabulating Index					
File folder					
Index Bristol					
Printing Bristol					
Postcard					
Coated Bristol					
Packaging, industrial and other					
Packaging, industrial and other, unbl. kraft					
Wrapping, unbl. kraft					
Bag and sack (exc. shipping), unbl. kraft					
Shipping sack, unbl. kraft					
Other converting (pkg'g & indus), unbl. kraft			X		
Packaging, industrial and other, bl. kraft					
Wrapping, bl.					
Bag and sack (exc. shipping), bl.					
Shipping sack, bl.					
Other converting (pkg'g & indus), bl.			X		
Special industrial papers			X		
Tissue					
Sanitary tissue					
Toilet tissue		65	X	X	
Facial tissue stock		65		X	
Napkin stock		65		X	
Towelling		65	X	X	
Wiper stock					
Other sanitary tissue					
Other tissue					
Paperboard, all grades					
Containerboard					
Unrboard					
Unrboard, unbl. kraft					
Unrboard, bl. kraft					
Unrboard, recycled					
Corrugating material					
Corrugating material, unbl. kraft					
Corrugating material, semi-chemical					
Corrugating material, recycled					
Chip and filler board, recycled					
Boxboard					
Folding boxboard					
Folding boxboard, bl. kraft					
Folding boxboard, recycled					
Setup boxboard, recycled					
Milk carton boxboard, bl. kraft					
Heavyweight food containers, bl. kraft					
Plate, dish & tray, bl. kraft					
Other boxboard, bl. kraft					
Other boxboard, recycled					
Other paperboard					

X - Quantity not reported.

[a][b][c] See notes at end of table.

Source: Lockwood Post's Directory of the Pulp, Paper and Allied Trades (1990), as coded by ERG.

Quantities and Grades of Paper and Board Produced at 99 of 104 Bleached Pulp Mills in EPA Study Group	56 Kimberly-Clark Corp.	57 Leaf River Forest Products	58 Lincoln Pulp and Paper	59 Longview Fiber Co.	60 Louisiana Pacific Corp.
	Coosa Pines Alabama	New Augusta Mississippi	Lincoln Maine	Longview Washington	Samoa California
TOTAL PAPER VOLUME	1,200	[b]	270	2,600	[b]
Paper, all grades					
Newsprint	X				
Printing and writing papers					
Uncoated groundwood					
Publishing and printing paper	X				
Converting paper					
Coated papers					
Uncoated free sheet					
Bond and writing			57		
Form bond					
Ledger					
Mimeograph					
Duplicating			57		
Manifold					
Papeterie and wedding					
Carbonless					
Opaque circular					
Cover and text papers					
M.F., E.F., and super calendered					
Offset			56		
White wave envelope					
Tablet					
Kraft envelope - brown					
Kraft envelope - bleached					
Other					
Thin papers					
Cotton fiber papers					
Bond and writing					
Other Business					
Technical and other					
Bleached Bristol					
Tabulating Index					
File folder					
Index Bristol					
Printing Bristol					
Postcard					
Coated Bristol					
Packaging, industrial and other					
Packaging, industrial and other, unbl. kraft					
Wrapping, unbl. kraft				200	
Bag and sack (exc. shipping), unbl. kraft				200	
Shipping sack, unbl. kraft					
Other converting (pkg'g & indus), unbl. kraft				200	
Packaging, industrial and other, bl. kraft					
Wrapping, bl.				200	
Bag and sack (exc. shipping), bl.				200	
Shipping sack, bl.					
Other converting (pkg'g & indus), bl.				200	
Special industrial papers					
Tissue					
Sanitary tissue					
Toilet tissue			33		
Facial tissue stock			33		
Napkin stock			34		
Towelling					
Wiper stock					
Other sanitary tissue					
Other tissue					
Paperboard, all grades					
Containerboard					
Linerboard					
Linerboard, unbl. kraft				700	
Linerboard, bl. kraft					
Linerboard, recycled					
Corrugating material					
Corrugating material, unbl. kraft				700	
Corrugating material, semi-chemical					
Corrugating material, recycled					
Chip and filler board, recycled					
Boxboard					
Folding boxboard					
Folding boxboard, bl. kraft					
Folding boxboard, recycled					
Setup boxboard, recycled					
Milk carton boxboard, bl. kraft					
Heavyweight food containers, bl. kraft					
Plate, dish & tray, bl. kraft					
Other boxboard, bl. kraft					
Other boxboard, recycled					
Other paperboard					

X - Quantity not reported.

[a][b][c] See notes at end of table.

Source: Lockwood Post's Directory of the Pulp, Paper and Allied Trades (1980), as coded by ERG.

Quantities and Grades of Paper and Board Produced at 99 of 104 Bleached Pulp Mills in EPA Study Group	61 Mead Corporation	62 Mead Corporation	63 Mead Corporation	64 Nekoosa Papers, Inc.	65 Nekoosa Papers, Inc.
	Escanaba Michigan	Chillicothe Ohio	Kingsport Tennessee	Ashdown Arkansas	Nekoosa Wisconsin
TOTAL PAPER VOLUME	1,480	1,171	550	1,350	675
Paper, all grades					
Newsprint					
Printing and writing papers					
Uncoated groundwood					
Publishing and printing paper					
Converting paper					
Coated papers	X	X	X		
Uncoated free sheet					
Bond and writing		X	X	X	X
Form bond				X	X
Ledger		X			
Mimeograph				X	
Duplicating				X	X
Manifold					
Papeterie and wedding		X			
Carbonless					X
Opaque circular					
Cover and text papers		X			
M.F., E.F., and super calendered			X		
Offset		X	X	X	
White wove envelope				X	
Tablet					
Kraft envelope - brown					
Kraft envelope - bleached					
Other			X		
Thin papers		X			
Cotton fiber papers					
Bond and writing					
Other Business					
Technical and other					
Bleached Bristols					
Tabulating index					
File folder					
Index Bristol					
Printing Bristol					
Postcard					
Coated Bristol					
Packaging, industrial and other					
Packaging, industrial and other, unbl. kraft					
Wrapping, unbl. kraft					
Bag and sack (exc. shipping), unbl. kraft					
Shipping sack, unbl. kraft					
Other converting (pkg g & indus), unbl. kraft					
Packaging, industrial and other, bl. kraft					
Wrapping, bl.					
Bag and sack (exc. shipping), bl.					
Shipping sack, bl.					
Other converting (pkg g & indus), bl.					
Special industrial papers					
Tissue					
Sanitary tissue					
Toilet tissue					
Facial tissue stock					
Napkin stock					
Towelings					
Wiper stock					
Other sanitary tissue					
Other tissue					
Paperboard, all grades					
Containerboard					
Linerboard					
Linerboard, unbl. kraft					
Linerboard, bl. kraft					
Linerboard, recycled					
Corrugating material					
Corrugating material, unbl. kraft					
Corrugating material, semi-chemical					
Corrugating material, recycled					
Chip and filler board, recycled					
Boxboard					
Folding boxboard					
Folding boxboard, bl. kraft					
Folding boxboard, recycled					
Setup boxboard, recycled					
Milk carton boxboard, bl. kraft					
Heavyweight food containers, bl. kraft					
Plate, dish & tray, bl. kraft					
Other boxboard, bl. kraft					
Other boxboard, recycled					
Other paperboard					

X - Quantity not reported.

[a][b][c] See notes at end of table.

Source: Lockwood Post's Directory of the Pulp, Paper and Allied Trades (1990), as coded by ERG.

Quantities and Grades of Paper and Board Produced at 99 of 104 Bleached Pulp Mills in EPA Study Group	66 Nekoosa Papers, Inc.	67 P.H. Glatfelter Co.	68 Penntech Papers, Inc.	69 Pope & Talbot, Inc.	70 Pottlatch Corp.
	Port Edwards Wisconsin	Spring Grove Pennsylvania	Johnsonburg Pennsylvania	Halsey Oregon	McGhee Arkansas
TOTAL PAPER VOLUME	440	800	400	[b]	500
Paper, all grades					
Newsprint					
Printing and writing papers					
Uncoated groundwood					
Publishing and printing paper					
Converting paper					
Coated papers		X	X		
Uncoated free sheet					
Bond and writing	X	X	X		
Form bond		X			
Ledger	X	X	X		
Mimeograph	X				
Duplicating	X				
Manifold					
Papeterie and wedding					
Carbonless					
Opaque circular	X	X			
Cover and text papers					
M.F., E.F., and super calendered		X	X		
Offset	X	X	X		
White wove envelope					
Tablet					
Kraft envelope - brown					
Kraft envelope - bleached					
Other	X	X	X		
Thin papers					
Cotton fiber papers					
Bond and writing					
Other Business					
Technical and other					
Bleached Bristol					
Tabulating index					
File folder					
Index Bristol					
Printing Bristol					
Postcard					
Coated Bristol					
Packaging, industrial and other					
Packaging, industrial and other, unbl. kraft					
Wrapping, unbl. kraft					
Bag and sack (exc. shipping), unbl. kraft					
Shipping sack, unbl. kraft					
Other converting (pkg'g & indust), unbl. kraft					
Packaging, industrial and other, bl. kraft					
Wrapping, bl.					
Bag and sack (exc. shipping), bl.					
Shipping sack, bl.					
Other converting (pkg'g & indust), bl.					
Special industrial papers	X				
Tissue					
Sanitary tissue					
Toilet tissue					
Facial tissue stock					
Napkin stock					
Towelling					
Wiper stock					
Other sanitary tissue					
Other tissue					
Paperboard, all grades					
Containerboard					
Linerboard					
Linerboard, unbl. kraft					
Linerboard, bl. kraft					
Linerboard, recycled					
Corrugating material					
Corrugating material, unbl. kraft					
Corrugating material, semi-chemical					
Corrugating material, recycled					
Chip and filler board, recycled					
Boxboard					
Folding boxboard					
Folding boxboard, bl. kraft					X
Folding boxboard, recycled					X
Setup boxboard, recycled					
Milk carton boxboard, bl. kraft					
Heavyweight food containers, bl. kraft					
Plate, dish & tray, bl. kraft					X
Other boxboard, bl. kraft					
Other boxboard, recycled					
Other paperboard					

X - Quantity not reported.

[a][b][c] See notes at end of table.

Source: Lockwood Post's Directory of the Pulp, Paper and Allied Trades (1990), as coded by ERG.

Quantities and Grades of Paper and Board Produced at 99 of 104 Bleached Pulp Mills in EPA Study Group	71	72	73	74	75
	Potlatch Corp. Lawiston Idaho	Potlatch Corp. Cloquet Minnesota	Proctor & Gamble Co. Mahopany Pennsylvania	Scott Paper Co. Mobile Alabama	Scott Paper Co. Hinckley Maine
TOTAL PAPER VOLUME	825	560	[a]	2,450	600
Paper, all grades					
Newsprint					
Printing and writing papers					
Uncoated groundwood					
Publishing and printing paper					
Converting paper					
Coated papers	X	X			600
Uncoated free sheet					
Bond and writing					
Form bond					
Ledger					
Mimeograph					
Duplicating					
Manifold					
Papeterie and wedding					
Carbonless					
Opaque circular					
Cover and text papers					
M.F., E.F., and super calendered					
Offset					
White wove envelope					
Tablet					
Kraft envelope - brown					
Kraft envelope - bleached					
Other					
Thin papers					
Cotton fiber papers					
Bond and writing					
Other Business					
Technical and other					
Bleached Bristols					
Tabulating Index					
File folder	X				
Index Bristol					
Printing Bristol					
Postcard					
Coated Bristol					
Packaging, industrial and other					
Packaging, industrial and other, unbl. kraft					
Wrapping, unbl. kraft					
Bag and sack (exc. shipping), unbl. kraft					
Shipping sack, unbl. kraft					
Other converting (pkg'g & indus), unbl. kraft					
Packaging, industrial and other, bl. kraft					
Wrapping, bl.					
Bag and sack (exc. shipping), bl.					
Shipping sack, bl.					
Other converting (pkg'g & indus), bl.					
Special industrial papers					
Tissue					
Sanitary tissue			X		
Toilet tissue					
Facial tissue stock					
Napkin stock					
Toweling					
Wiper stock					
Other sanitary tissue					
Other tissue					
Paperboard, all grades					
Containerboard					
Linerboard					
Linerboard, unbl. kraft				X	
Linerboard, bl. kraft				X	
Linerboard, recycled					
Corrugating material					
Corrugating material, unbl. kraft					
Corrugating material, semi-chemical					
Corrugating material, recycled					
Chip and filler board, recycled					
Boxboard					
Folding boxboard					
Folding boxboard, bl. kraft	X				
Folding boxboard, recycled					
Setup boxboard, recycled					
Milk carton boxboard, bl. kraft	X				
Heavyweight food containers, bl. kraft					
Plate, dish & tray, bl. kraft	X				
Other boxboard, bl. kraft					
Other boxboard, recycled					
Other paperboard					

X - Quantity not reported.

[a][b][c] See notes at end of table.

Source: Lockwood Post's Directory of the Pulp, Paper and Allied Trades (1990), as coded by ERG.

Quantities and Grades of Paper and Board Produced at 99 of 104 Bleached Pulp Mills in EPA Study Group	76 Scott Paper Co.	77 Scott Paper Co.	78 Scott Paper Co.	79 Simpson Paper Co.	80 Simpson Paper Co.
	Westbrook Maine	Muskegon Michigan	Everett Washington	Anderson California	Fairhaven California
TOTAL PAPER VOLUME	[a]	[a]	[a]	420	[b]
Paper, all grades					
Newsprint					
Printing and writing papers					
Uncoated groundwood					
Publishing and printing paper					
Converting paper					
Coated papers	X	X		X	
Uncoated free sheet					
Bond and writing				X	
Form bond					
Ledger					
Mimeograph				X	
Duplicating				X	
Manifold					
Papeterie and wedding					
Carbonless					
Opaque circular					
Cover and text papers	X				
M.F., E.F., and super calendered					
Offset					
White wove envelope					
Tablet					
Kraft envelope - brown					
Kraft envelope - bleached					
Other	X			X	
Thin papers					
Cotton fiber papers					
Bond and writing					
Other Business					
Technical and other					
Bleached Bristol					
Tabulating index					
File folder					
Index Bristol					
Printing Bristol					
Postcard					
Coated Bristol					
Packaging, industrial and other					
Packaging, industrial and other, unbl. kraft					
Wrapping, unbl. kraft					
Bag and sack (exc. shipping), unbl. kraft					
Shipping sack, unbl. kraft					
Other converting (pkg'g & indus), unbl. kraft					
Packaging, industrial and other, bl. kraft					
Wrapping, bl.					
Bag and sack (exc. shipping), bl.					
Shipping sack, bl.					
Other converting (pkg'g & indus), bl.					
Special industrial papers					
Tissue					
Sanitary tissue					
Toilet tissue			X		
Facial tissue stock			X		
Napkin stock			X		
Towelling			X		
Wiper stock					
Other sanitary tissue					
Other tissue					
Paperboard, all grades					
Containerboard					
Linerboard					
Linerboard, unbl. kraft					
Linerboard, bl. kraft					
Linerboard, recycled					
Corrugating material					
Corrugating material, unbl. kraft					
Corrugating material, semi-chemical					
Corrugating material, recycled					
Chip and filler board, recycled					
Boxboard					
Folding boxboard					
Folding boxboard, bl. kraft					
Folding boxboard, recycled					
Setup boxboard, recycled					
Milk carton boxboard, bl. kraft					
Heavyweight food containers, bl. kraft					
Plate, dish & tray, bl. kraft					
Other boxboard, bl. kraft					
Other boxboard, recycled					
Other paperboard					

X - Quantity not reported.

[a][b][c] See notes at end of table.

Source: Lockwood Post's Directory of the Pulp, Paper and Allied Trades (1990), as coded by ERG.

Quantities and Grades of Paper and Board Produced at 99 of 104 Bleached Pulp Mills in EPA Study Group	81 Simpson Paper Co.	82 Simpson Paper Co.	83 St. Joe Paper Co.	84 Stone Container Corp.	85 Stone Container Corp.
	Pasadena Texas	Tacoma Washington	Port St. Joe Florida	Snowflake Arizona	Panama City Florida
TOTAL PAPER VOLUME	750	870	1,400	1,250	800
Paper, all grades					
Newsprint				790	
Printing and writing papers					
Uncoated groundwood					
Publishing and printing paper					
Converting paper					
Coated papers	X				
Uncoated free sheet					
Bond and writing					
Form bond					
Ledger					
Mimeograph					
Duplicating					
Manifold					
Papeterie and wedding					
Carbonless					
Opaque circular					
Cover and text papers					
M.F., E.F., and super calendered					
Offset	X				
White wove envelope	X				
Tablet	X				
Kraft envelope - brown					
Kraft envelope - bleached					
Other					
Thin papers					
Cotton fiber papers					
Bond and writing					
Other Business					
Technical and other					
Bleached Bristol					
Tabulating index					
File folder					
Index Bristol					
Printing Bristol					
Postcard					
Coated Bristol					
Packaging, industrial and other					
Packaging, industrial and other, unbl. kraft					
Wrapping, unbl. kraft					
Bag and sack (exc. shipping), unbl. kraft		X			
Shipping sack, unbl. kraft					
Other converting (pkg'g & indus), unbl. kraft		X			
Packaging, industrial and other, bl. kraft					
Wrapping, bl.					
Bag and sack (exc. shipping), bl.		X			
Shipping sack, bl.					
Other converting (pkg'g & indus), bl.					
Special industrial papers					
Tissue					
Sanitary tissue					
Toilet tissue					
Facial tissue stock					
Napkin stock					
Towelling					
Wiper stock					
Other sanitary tissue					
Other tissue					
Paperboard, all grades					
Containerboard					
Linerboard					
Linerboard, unbl. kraft		X	X	230	800
Linerboard, bl. kraft		X	X	230	
Linerboard, recycled					
Corrugating material					
Corrugating material, unbl. kraft					
Corrugating material, semi-chemical					
Corrugating material, recycled					
Chip and filler board, recycled					
Boxboard					
Folding boxboard					
Folding boxboard, bl. kraft					
Folding boxboard, recycled					
Setup boxboard, recycled					
Milk carton boxboard, bl. kraft					
Heavyweight food containers, bl. kraft					
Plate, dish & tray, bl. kraft					
Other boxboard, bl. kraft					
Other boxboard, recycled					
Other paperboard					

X - Quantity not reported.

[a][b][c] See notes at end of table.

Source: Lockwood Post's Directory of the Pulp, Paper and Allied Trades (1990), as coded by ERG.

Quantities and Grades of Paper and Board Produced at 99 of 104 Bleached Pulp Mills in EPA Study Group	86 Stone Container Corp.	87 Union Camp Corp.	88 Union Camp Corp.	89 Wausau Pulp and Paper	90 Westvaco Corp.
	Missoula Montana	Eastover South Carolina	Franklin Virginia	Brokaw Wisconsin	Wickliffe Kentucky
TOTAL PAPER VOLUME	1,910	600	1,900	480	600
Paper, all grades					
Newsprint					
Printing and writing papers					
Uncoated groundwood					
Publishing and printing paper					
Converting paper					
Coated papers					
Uncoated free sheet		600			
Bond and writing			X		
Form bond					
Ledger					
Mimeograph			X		
Duplicating					
Manifold					
Paperette and wedding				X	
Carbonless					
Opaque circular					
Cover and text papers				X	
M.F., E.F., and super calendered					
Offset			X	X	X
White wove envelope				X	X
Tablet					
Kraft envelope - brown					
Kraft envelope - bleached					
Other			X	X	X
Thin papers					
Cotton fiber papers					
Bond and writing					
Other Business					
Technical and other					
Bleached Bristol					
Tabulating index					
File folder					
Index Bristol			X	X	
Printing Bristol			X		
Postcard			X		
Coated Bristol				X	
Packaging, industrial and other					
Packaging, industrial and other, unbl. kraft					
Wrapping, unbl. kraft					
Bag and sack (exc. shipping), unbl. kraft					
Shipping sack, unbl. kraft					
Other converting (pkg'g & indus), unbl. kraft					
Packaging, industrial and other, bl. kraft					
Wrapping, bl.					
Bag and sack (exc. shipping), bl.					
Shipping sack, bl.					
Other converting (pkg'g & indus), bl.					
Special industrial papers				X	
Tissue					
Sanitary tissue					
Toilet tissue					
Facial tissue stock					
Napkin stock					
Towelling					
Wiper stock					
Other sanitary tissue					
Other tissue					
Paperboard, all grades					
Containerboard					
Linerboard					
Linerboard, unbl. kraft	X				
Linerboard, bl. kraft					
Linerboard, recycled					
Corrugating material					
Corrugating material, unbl. kraft					
Corrugating material, semi-chemical					
Corrugating material, recycled					
Chip and filler board, recycled					
Boxboard					
Folding boxboard					
Folding boxboard, bl. kraft			X		
Folding boxboard, recycled					
Setup boxboard, recycled					
Milk carton boxboard, bl. kraft					
Heavyweight food containers, bl. kraft					
Plate, dish & tray, bl. kraft					
Other boxboard, bl. kraft					
Other boxboard, recycled					
Other paperboard					

X - Quantity not reported.

(a)(b)(c) See notes at end of table.

Source: Lockwood Post's Directory of the Pulp, Paper and Allied Trades (1990), as coded by ERG.

Quantities and Grades of Paper and Board Produced at 99 of 104 Bleached Pulp Mills in EPA Study Group	91	92	93	94	95
	Westvaco Corp. Luke Maryland	Westvaco Corp. Covington Virginia	Weyerhaeuser Co. New Bern North Carolina	Weyerhaeuser Co. Plymouth North Carolina	Weyerhaeuser Co. Cosmopolis Washington
TOTAL PAPER VOLUME	1,174	2,000	(b)	(a)	(b)
Paper, all grades					
Newsprint					
Printing and writing papers					
Uncoated groundwood					
Publishing and printing paper					
Covering paper					
Coated papers					
Uncoated free sheet					
Bond and writing					
Form bond					
Ledger					
Mimeograph					
Duplicating					
Manifold					
Papeterie and wedding					
Carbonless					
Opaque circular					
Cover and text papers	X				
M.F., E.F., and super calendered					
Offset	X				
White wove envelope					
Tablet					
Kraft envelope - brown					
Kraft envelope - bleached					
Other	X				
Thin papers					
Cotton fiber papers					
Bond and writing					
Other Business					
Technical and other					
Bleached Bristol					
Tabulating index					
File folder					
Index Bristol					
Printing Bristol					
Postcard					
Coated Bristol					
Packaging, industrial and other					
Packaging, industrial and other, unbl. kraft					
Wrapping, unbl. kraft					
Bag and sack (exc. shipping), unbl. kraft					
Shipping sack, unbl. kraft					
Other converting (pkg'g & Indus), unbl. kraft					
Packaging, industrial and other, bl. kraft					
Wrapping, bl.					
Bag and sack (exc. shipping), bl.					
Shipping sack, bl.					
Other converting (pkg'g & Indus), bl.					
Special industrial papers					
Tissue					
Sanitary tissue					
Toilet tissue					
Facial tissue stock					
Napkin stock					
Towelling					
Wiper stock					
Other sanitary tissue					
Other tissue					
Paperboard, all grades					
Containerboard					
Linerboard					
Linerboard, unbl. kraft				X	
Linerboard, bl. kraft				X	
Linerboard, recycled					
Corrugating material				X	
Corrugating material, unbl. kraft					
Corrugating material, semi-chemical		X			
Corrugating material, recycled					
Chip and filler board, recycled					
Boxboard					
Folding boxboard					
Folding boxboard, bl. kraft		X			
Folding boxboard, recycled					
Setup boxboard, recycled					
Milk carton boxboard, bl. kraft		X			
Heavyweight food containers, bl. kraft					
Plate, dish & tray, bl. kraft		X			
Other boxboard, bl. kraft					
Other boxboard, recycled					
Other paperboard					

X - Quantity not reported.

(a)(b)(c) See notes at end of table.

Source: Lockwood Post's Directory of the Pulp, Paper and Allied Trades (1990), as coded by ERG.

Quantities and Grades of Paper and Board Produced at 99 of 104 Bleached Pulp Mills In EPA Study Group	96	97	98	99
	Weyerhaeuser Co. Everett Washington	Weyerhaeuser Co. Longview Washington	Weyerhaeuser Co. Rothchild Wisconsin	Weyerhaeuser Co. Hawesville Kentucky
TOTAL PAPER VOLUME	(b)	855	350	(b)
Paper, all grades				
Newsprint				
Printing and writing papers				
Uncoated groundwood				
Publishing and printing paper				
Converting paper				
Coated papers				
Uncoated free sheet			X	
Bond and writing				
Form bond				
Ledger				
Mimeograph				
Duplicating				
Manifold				
Paperie and wedding				
Carbonless				
Opaque circular				
Cover and text papers				
M.F., E.F., and super calendered				
Offset				
White wove envelope				
Tablet				
Kraft envelope - brown				
Kraft envelope - bleached				
Other				
Thin papers				
Cotton fiber papers				
Bond and writing				
Other Business				
Technical and other				
Bleached Bristol				
Tabulating index				
File folder				
Index Bristol				
Printing Bristol				
Postcard				
Coated Bristol				
Packaging, industrial and other				
Packaging, industrial and other, unbl. kraft				
Wrapping, unbl. kraft				
Bag and sack (exc. shipping), unbl. kraft				
Shipping sack, unbl. kraft				
Other converting (pkg'g & indus), unbl. kraft				
Packaging, industrial and other, bl. kraft				
Wrapping, bl.				
Bag and sack (exc. shipping), bl.				
Shipping sack, bl.				
Other converting (pkg'g & indus), bl.				
Special industrial papers				
Tissue				
Sanitary tissue				
Toilet tissue				
Facial tissue stock				
Napkin stock				
Towelstock				
Wiper stock				
Other sanitary tissue				
Other tissue				
Paperboard, all grades				
Containerboard				
Linerboard				
Linerboard, unbl. kraft				
Linerboard, bl. kraft				
Linerboard, recycled				
Corrugating material				
Corrugating material, unbl. kraft				
Corrugating material, semi-chemical		255		
Corrugating material, recycled				
Chip and filler board, recycled				
Boxboard				
Folding boxboard				
Folding boxboard, bl. kraft				
Folding boxboard, recycled				
Setup boxboard, recycled				
Milk carton boxboard, bl. kraft				
Heavyweight food containers, bl. kraft				
Plate, dish & tray, bl. kraft				
Other boxboard, bl. kraft		800		
Other boxboard, recycled				
Other paperboard				

(a) Due to the lack of a consistent reporting scheme for products in the Lockwood Post directory, mill outputs were coded to varying levels of detail.

(b) Mill produces market pulp only.

(c) Quantity not reported or combined with market pulp quantities.

APPENDIX 2.C

MILLS AND FIRMS PRODUCING PRODUCTS WITH HIGH OR MEDIUM BLEACHED PULP CONTENT

APPENDIX 2.C
MILLS AND FIRMS PRODUCING PRODUCTS WITH HIGH OR MEDIUM
BLEACHED PULP CONTENT

This section presents additional data on mill outputs compiled from self-reported data contained in the Lockwood-Post Directory of the Pulp, Paper, and Allied Trades. It examines the numbers of mills which produce in each of the product categories identified as having high or medium bleached pulp content.

The Lockwood-Post's data used here appears to be of reasonable quality; nevertheless several caveats are necessary. First, because there is no consistent system used by mills to report their outputs, the responses may suffer from a reporting bias, i.e. mills producing the same product may describe and report it differently. Second, some mills provide production volumes while other simply list the products. Thus, aggregate production quantities are generally not available. A final problem is that some mills provide greater detail in describing their output than others. For example, one may report production of "single-ply toilet tissue" while another indicates only that "tissue" is produced. The products were coded to whatever level of detail was appropriate, given the directory entries for each mill.

As shown in Table 2.C-1, there are few categories of product where more than 10-15 mills report production. The two products with the highest number of mills are offset and coated papers (19 mills) and bond and writing (17 mills), both of which happen to be among the highest volume paper grades. Following these, there are 15 mills reporting production in the "other" uncoated free sheet category and 13 mills reporting production of white wove envelope.

Tables 2.C-2 to 2.C-9 list the mills which produce in each of the high and medium bleached pulp content product categories. Within the high bleached pulp content categories, a total of 19 mills produce coated papers (both groundwood and free sheet), 37 mills report production of uncoated free sheet grades, 3 mills produce thin papers, 9 each produce bleached bristols and bleached packaging and industrial papers, and 24 produce bleached paperboard products. In the medium bleached pulp content categories, 3 mills produce special industrial papers and 11 produce tissue grades.

Table 2.C-1.

Number of Mills Coded in Product Categories
with High and Medium Bleached Pulp Content

Type and Grade of Product [f]	No. of Mills [a]	% of All Mills
<u>HIGH BLEACHED PULP CONTENT</u>		
Coated papers	19	19.2%
Uncoated free sheet [b]	37	37.4%
Bond and writing	17	17.2%
Form bond	7	7.1%
Ledger	8	8.1%
Mimeograph	7	7.1%
Duplicating	10	10.1%
Manifold	0	0.0%
Papeterie and wedding	2	2.0%
Carbonless	1	1.0%
Opaque circular	5	5.1%
Cover and text papers	7	7.1%
M.F., E.F., and super calendered	3	3.0%
Offset	19	19.2%
White wove envelope	13	13.1%
Tablet	7	7.1%
Kraft envelope - brown	0	0.0%
Kraft envelope - bleached	0	0.0%
Other	15	15.2%
Thin papers	3	3.0%
Bleached Bristols [c]	9	9.1%
Tabulating index	0	0.0%
File folder	3	3.0%
Index Bristol	3	3.0%
Printing Bristol	1	1.0%
Postcard	1	1.0%
Coated Bristol	2	2.0%
Bleached packaging & industrial papers [d]	9	9.1%
Wrapping	3	3.0%
Bag and sack (exc. shipping)	2	2.0%
Shipping sack	1	1.0%
Other converting (pkg'g & indust)	5	5.1%
Solid bleached paperboard	24	24.0%
Linerboard	10	10.1%
Folding boxboard	9	9.1%
Milk carton boxboard	7	7.1%
Heavyweight food containerboard	5	5.1%
Plate, dish & tray board	8	8.1%
Other boxboard	1	1.0%
<u>MEDIUM BLEACHED PULP CONTENT</u>		
Special industrial papers	3	3.0%
Tissue [e]	11	11.1%
Sanitary tissue	2	2.0%
Toilet tissue	6	6.1%
Facial tissue stock	5	5.1%
Napkin stock	5	5.1%
Towelling	5	5.1%
Wiper stock	0	0.0%
Other sanitary tissue	0	0.0%
Other tissue	0	0.0%

[a] Sub-categories will not add to category totals since mills may report output in several subcategories.

[b] 4 mills were coded simply as "uncoated free sheet".

[c] 2 mills were coded simply as "bleached bristol".

[d] 9 mills were coded as simply "bleached packaging & industrial paper".

[e] 11 mills were coded as simply "tissue".

Source: Lockwood-Post's Directory of Pulp, Paper, & Allied Trades (1990), as coded by ERG.

Table 2.C-2.

Mills Producing Coated Papers
(High Bleached Pulp Content)

Firm	Town	State
1 Boise Cascade Corp.	Rumford	Maine
2 Bowater Corp.	Catawba	South Carolina
3 Federal Paper Board Co.	Riegelwood	North Carolina
4 Finch Pruyn & Co., Inc.	Glenns Falls	New York
5 International Paper Co.	Pine Bluff	Arkansas
6 International Paper Co.	Jay	Maine
7 James River Corp.	St. Francesville	Louisiana
8 Mead Corporation	Escanaba	Michigan
9 Mead Corporation	Chillicothe	Ohio
10 Mead Corporation	Kingsport	Tennessee
11 Penntech Papers, Inc.	Johnsonburg	Pennsylvania
12 Pottlatch Corp.	Lewiston	Idaho
13 Pottlatch Corp.	Cloquet	Minnesota
14 P.H. Glatfelter Co.	Spring Grove	Pennsylvania
15 Scott Paper Co.	Hinckley	Maine
16 Scott Paper Co.	Westbrook	Maine
17 Scott Paper Co.	Muskegon	Michigan
18 Simpson Paper Co.	Anderson	California
19 Simpson Paper Co.	Pasadena	Texas

Source: Lockwood-Post's Directory of the Pulp, Paper, & Allied Trades (1990),
as coded by ERG.

Table 2.C-3.

Mills Producing Uncoated Free Sheet
(High Bleached Pulp Content)

Firm	Town	State
1 Badger Paper Mills, Inc.	Peshtigo	Wisconsin
2 Boise Cascade Corp.	International Falls	Minnesota
3 Boise Cascade Corp.	Jackson	Alabama
4 Boise Cascade Corp.	Rumford	Maine
5 Boise Cascade Corp.	St. Helens	Oregon
6 Champion International	Canton	North Carolina
7 Champion International	Cantonment	Florida
8 Champion International	Courtland	Alabama
9 Finch Pruyn & Co., Inc.	Glenns Falls	New York
10 Flambeau Papers (div. Pentai	Park Falls	Wisconsin
11 Georgia-Pacific Corp.	Crosset	Arkansas
12 Georgia-Pacific Corp.	Woodland	Maine
13 Hammermill Paper Co.	Erie	Pennsylvania
14 Hammermill Paper Co.	Selma	Alabama
15 International Paper Co.	Georgetown	South Carolina
16 International Paper Co.	Jay	Maine
17 International Paper Co.	Mobile	Alabama
18 International Paper Co.	Ticonderoga	New York
19 James River Corp.	Cames	Washington
20 James River Corp.	Clatskanie	Oregon
21 Lincoln Pulp and Paper	Lincoln	Maine
22 Mead Corporation	Chillicothe	Ohio
23 Mead Corporation	Kingsport	Tennessee
24 Nekoosa Papers, Inc.	Ashdown	Arkansas
25 Nekoosa Papers, Inc.	Nekoosa	Wisconsin
26 Nekoosa Papers, Inc.	Port Edwards	Wisconsin
27 P.H. Glatfelter Co.	Spring Grove	Pennsylvania
28 Penntech Papers, Inc.	Johnsonburg	Pennsylvania
29 Scott Paper Co.	Westbrook	Maine
30 Simpson Paper Co.	Anderson	California
31 Simpson Paper Co.	Pasadena	Texas
32 Union Camp Corp.	Eastover	South Carolina
33 Union Camp Corp.	Franklin	Virginia
34 Wausau Pulp and Paper	Brokaw	Wisconsin
35 Westvaco Corp.	Luke	Maryland
36 Westvaco Corp.	Wickliffe	Kentucky
37 Weyerhaeuser Co.	Rothchild	Wisconsin

Source: Lockwood-Post's Directory of the Pulp, Paper, & Allied Trades (1990),
as coded by ERG.

Table 2.C-4.

Mills Producing Thin Papers
(High Bleached Pulp Content)

Firm	Town	State
1 Appleton Papers, Inc.	Roaring Springs	Pennsylvania
2 International Paper Co.	Jay	Maine
3 Mead Corporation	Chillicothe	Ohio

Source: Lockwood-Post's Directory of the Pulp, Paper, & Allied Trades (1990),
as coded by ERG.

Table 2.C-5.

Mills Producing Bleached Bristols
(High Bleached Pulp Content)

Firm	Town	State
1 Brunswick Pulp and Paper	Brunswick	Georgia
2 Federal Paper Board Co.	Augusta	Georgia
3 Federal Paper Board Co.	Riegelwood	North Carolina
4 Hammermill Paper Co.	Erie	Pennsylvania
5 International Paper Co.	Georgetown	South Carolina
6 International Paper Co.	Moss Point	Mississippi
7 Pottlatch Corp.	Lewiston	Idaho
8 Union Camp Corp.	Franklin	Virginia
9 Wausau Pulp and Paper	Brokaw	Wisconsin

Source: Lockwood-Post's Directory of the Pulp, Paper, & Allied Trades (1990),
as coded by ERG.

Table 2.C-6.

Mills Producing Bleached Packaging & Industrial Papers
(High Bleached Pulp Content)

Firm	Town	State
1 Badger Paper Mills, Inc.	Peshtigo	Wisconsin
2 Champion International	Cantonment	Florida
3 Gilman Paper Co.	St. Marys	Georgia
4 International Paper Co.	Mobile	Alabama
5 International Paper Co.	Moss Point	Mississippi
6 James River Corp.	Cames	Washington
7 James River Corp.	St. Francesville	Louisiana
8 Longview Fiber Co.	Longview	Washington
9 Simpson Paper Co.	Tacome	Washington

Source: Lockwood-Post's Directory of the Pulp, Paper, & Allied Trades (1990),
as coded by ERG.

Table 2.C-7.

Mills Producing Bleached Paperboard
(High Bleached Pulp Content)

Firm	Town	State
1 Brunswick Pulp and Paper	Brunswick	Georgia
2 Champion International	Canton	North Carolina
3 Champion International	Cantonment	Florida
4 Container Corp. of America	Brewton	Alabama
5 Federal Paper Board Co.	Augusta	Georgia
6 Federal Paper Board Co.	Riegelwood	North Carolina
7 Gaylord Container Corp.	Antioch	California
8 Georgia-Pacific Corp.	Crosset	Arkansas
9 Gilman Paper Co.	St. Marys	Georgia
10 Gulf States Paper Corp.	Demopolis	Alabama
11 International Paper Co.	Georgetown	South Carolina
12 International Paper Co.	Moss Point	Mississippi
13 International Paper Co.	Pine Bluff	Arkansas
14 International Paper Co.	Texarkana	Texas
15 Pottlatch Corp.	Lewiston	Idaho
16 Pottlatch Corp.	McGhee	Arkansas
17 Scott Paper Co.	Mobile	Alabama
18 Simpson Paper Co.	Tacoma	Washington
19 St. Joe Paper Co.	Port St. Joe	Florida
20 Stone Container Corp.	Snowflake	Arizona
21 Union Camp Corp.	Franklin	Virginia
22 Westvaco Corp.	Covington	Virginia
23 Weyerhaeuser Co.	Longview	Washington
24 Weyerhaeuser Co.	Plymouth	North Carolina

Source: Lockwood-Post's Directory of the Pulp, Paper, & Allied Trades (1990),
as coded by ERG.

Table 2.C-8.

Mills Producing Special Industrial Papers
(Medium Bleached Pulp Content)

Firm	Town	State
1 James River Corp.	Carnes	Washington
2 Nekoosa Papers, Inc.	Port Edwards	Wisconsin
3 Wausau Pulp and Paper	Brokaw	Wisconsin

Source: Lockwood-Post's Directory of the Pulp, Paper, & Allied Trades (1990),
as coded by ERG.

Table 2.C-9.

Mills Producing Tissue
(Medium Bleached Pulp Content)

Firm	Town	State
1 Boise Cascade Corp.	St. Helens	Oregon
2 Georgia-Pacific Corp.	Bellingham	Washington
3 Georgia-Pacific Corp.	Crossett	Arkansas
4 Georgia-Pacific Corp.	Palatka	Florida
5 James River Corp.	Camas	Washington
6 James River Corp.	Clatskanie	Oregon
7 James River Corp.	Green Bay	Wisconsin
8 James River Corp.	Old Town	Maine
9 Lincoln Pulp and Paper	Lincoln	Maine
10 Proctor & Gamble Co.	Mahopany	Pennsylvania
11 Scott Paper Co.	Everett	Washington

Source: Lockwood-Post's Directory of the Pulp, Paper, & Allied Trades (1990),
as coded by ERG.

APPENDIX 2.D

BUREAU OF CENSUS DATA

APPENDIX 2.D

BUREAU OF CENSUS DATA

Further data on the percent of paper and board grades that are bleached was obtained from a special tabulation by the U.S. Bureau of the Census from its Pulp, Paper, and Board Survey (MA26A). The survey covers all pulp and paper mills in the U.S., and is designed to collect information on aggregate U.S. shipments of pulp, paper, and paperboard products. For purposes of this analysis, shipment data was provided separately for:

- (1) mills that produce bleached kraft pulp (referred to here as bleached kraft producers);
- (2) mills that consume, but do not produce, bleached kraft pulp (bleached kraft consumers);
and
- (3) mills that neither produce nor consume bleached kraft pulp (other mills).

Table 2.D-1 shows 1989 shipments for these three mill categories.

Since mills in the "bleached kraft producers" and "bleached kraft consumers" categories may also produce unbleached products, Table 2.D-1 does not serve to show the exact percentages of the paper grades that are produced in a bleached form. However, the table does indicate the minimum quantity and percentage of paper and board grades that are produced in an unbleached form since all shipments by "other mills" are unbleached. Therefore, from the table, it can be seen that a minimum of about 44% of all paper and board is unbleached. Specific grades with a relatively high minimum percentage of unbleached shipments include: newsprint (minimum of 24% unbleached), uncoated groundwood paper (8%), packaging and industrial converting paper (44%), sanitary tissue (8%), tissue paper excluding sanitary and thin (28%), solid wood pulp furnish paperboard (68%), recycled paperboard (89%), and construction paper and board (97%). This information is consistent with the estimates of bleached virgin pulp content by product that was presented in Table 2.19.

Table 2.D-1.

1989 Shipments of Paper and Board, by Type of Producer
(Quantity in short tons)

Product Description	Producers of Bleached Kraft Pulp [a]		Consumers of Bleached Kraft Pulp [b]		Other Mills [c]		TOTAL	
	Shipments	Percent	Shipments	Percent	Shipments	Percent	Shipments	Percent
All Grades	28,913,397	36.8%	15,324,271	19.5%	34,429,561	43.8%	78,667,229	100.0%
Paper	20,352,712	53.5%	13,538,437	35.6%	4,182,404	11.0%	38,073,553	100.0%
Printing, writing, and related papers	16,649,763	59.7%	9,605,676	34.5%	1,623,522	5.8%	27,878,961	100.0%
Newsprint	3,092,989	51.3%	1,474,980	24.5%	1,455,931	24.2%	6,023,900	100.0%
Uncoated groundwood	375,983	21.3%	1,251,574	71.0%	135,978	7.7%	1,763,535	100.0%
Publication and printing	285,442	19.5%	1,051,279	71.7%	128,690	8.8%	1,465,411	100.0%
Form bond	[D]		[D]		--		[D]	
Other converting and misc. groundwood	[D]		106,033	69.9%	[D]		151,797	100.0%
Body stock for coating	[D]		[D]		--		[D]	
Clay coated printing & converted paper	3,922,315	52.0%	3,621,875	48.0%	--	0.0%	7,544,190	100.0%
Coated groundwood & prime coated body stock	1,521,291	36.7%	2,629,466	63.3%	--	0.0%	4,150,757	100.0%
Coated free sheet	2,401,024	70.8%	992,409	29.2%	--	0.0%	3,393,433	100.0%
Coated one side	338,052	58.1%	243,323	41.9%	--	0.0%	581,375	100.0%
Coated two sides	2,062,972	73.4%	749,086	26.6%	--	0.0%	2,812,058	100.0%
Uncoated free sheet	8,052,566	74.1%	2,789,348	25.7%	27,894	0.3%	10,869,808	100.0%
Writing, chemical woodpulp	4,904,400	77.7%	[D]		[D]		6,314,408	100.0%
Bond and writing	2,428,056	79.0%	[D]		[D]		3,074,539	100.0%
Form bond in rolls	1,581,621	79.9%	[D]		[D]		1,979,954	100.0%
Ledger	50,201	84.0%	9,586	16.0%	--	0.0%	59,787	100.0%
Mimeograph, all woodpulp furnishes	[D]		[D]		--	0.0%	25,270	100.0%
Gelatin & spirit process duplicating	20,436	66.8%	10,154	33.2%	--	0.0%	30,590	100.0%
Papeterie and wedding	32,982	64.9%	17,802	35.1%	--	0.0%	50,785	100.0%
Body stock for communication, copying, and related papers	314,335	90.5%	32,948	9.5%	--	0.0%	347,283	100.0%
Other technical & reproduction papers	[D]		[D]		--	0.0%	344,294	100.0%
Tablet	272,241	79.6%	69,888	20.4%	--	0.0%	342,129	100.0%
Other	39,915	66.8%	19,862	33.2%	--	0.0%	59,777	100.0%

(Cont.)

Table 2.D-1. (cont.)

1989 Shipments of Paper and Board, by Type of Producer
(Quantity in short tons)

Product Description		Producers of Bleached Kraft Pulp [a]		Consumers of Bleached Kraft Pulp [b]		Other Mills [c]		TOTAL	
		Shipments	Percent	Shipments	Percent	Shipments	Percent	Shipments	Percent
Paper (cont.)	Publication and printing	1,801,815	66.4%	894,243	32.9%	17,970	0.7%	2,714,028	100.0%
	Plain, including M.F., E.F., antique, bulking, eggshell, & supercalendered	[D]		[D]		--	0.0%	324,028	100.0%
	Offset	1,171,794	65.6%	614,211	34.4%	--	0.0%	1,786,005	100.0%
	Other publication & printing freesheet	[D]		[D]		[D]		603,995	100.0%
	Cover and text papers	193,506	43.0%	[D]		[D]		449,622	100.0%
	Other converting & misc. freesheet	1,152,845	82.8%	[D]		[D]		1,391,750	100.0%
	Envelope (white woven)	698,531	95.5%	33,190	4.5%	--	0.0%	731,721	100.0%
	Kraft envelope-bleached & brown	348,488	95.8%	[D]		[D]		363,732	100.0%
	Body stock for coating	105,826	35.7%	[D]		[D]		296,297	100.0%
	Bleached bristols	[D]		65,745	5.3%	[D]		1,252,243	100.0%
	Tag and file folder	[D]		[D]		--	0.0%	438,402	100.0%
	Other uncoated bristols, including tabulating card stock, index, printing, and postcard	226,396	66.8%	[D]		[D]		338,797	100.0%
	Coated bristols	[D]		[D]		--	0.0%	475,044	100.0%
	Cotton fiber writing paper & thin paper	[D]		402,154	94.6%	[D]		425,285	100.0%
	Writing, cotton fiber	[D]		158,714	97.2%	[D]		163,225	100.0%
	Bond and writing	[D]		[D]		[D]		133,053	100.0%
	Other	--	0.0%	[D]		[D]		30,172	100.0%
	Thin paper	[D]		[D]		--	0.0%	262,060	100.0%
	Packaging & industrial converting paper	1,349,881	28.5%	1,313,349	27.7%	2,080,345	43.9%	4,743,575	100.0%
	Unbleached kraft packaging and industrial converting paper	739,644	25.0%	256,368	8.7%	1,956,859	66.3%	2,952,871	100.0%
	Wrapping	[D]		[D]		[D]		68,113	100.0%
	Shipping sack	260,257	38.6%	[D]		[D]		673,696	100.0%
	Bag and sack, other than shipping sack	338,708	20.4%	103,527	6.2%	1,215,524	73.3%	1,657,759	100.0%
	Specialty packaging	[D]		[D]		[D]		68,417	100.0%
	Other converting, including creping	96,217	19.8%	129,339	26.7%	259,330	53.5%	484,886	100.0%

(Cont.)

Table 2.D-1. (cont.)

1989 Shipments of Paper and Board, by Type of Producer
(Quantity in short tons)

Product Description		Producers of Bleached Kraft Pulp [a]		Consumers of Bleached Kraft Pulp [b]		Other Mills [c]		TOTAL	
		Shipments	Percent	Shipments	Percent	Shipments	Percent	Shipments	Percent
Paper (cont.)	Packaging & Industrial converting paper, except unbleached kraft wrapping	560,841	50.2%	475,412	42.6%	80,526	7.2%	1,116,779	100.0%
	Wrapping	33,740	67.0%	[D]		[D]		50,381	100.0%
	Shipping sack	155,404	68.3%	[D]		[D]		227,608	100.0%
	Other bag and sack	[D]		[D]		--	0.0%	230,758	100.0%
	Other converting	81,830	53.4%	71,333	46.6%	--	0.0%	153,163	100.0%
	Specialty packaging	[D]		[D]		--	0.0%	206,950	100.0%
	Glassine, greaseproof, & vegetable parchment	[D]		[D]		--	0.0%	247,919	100.0%
	Specialty Industrial paper, except specialty packaging	49,396	7.3%	581,569	86.3%	42,960	6.4%	673,925	100.0%
	Tissue	2,353,068	43.2%	2,619,412	48.1%	478,537	8.8%	5,451,017	100.0%
	Sanitary paper	2,334,863	44.1%	2,522,134	47.7%	434,075	8.2%	5,291,072	100.0%
	Toilet tissue	1,062,294	50.6%	924,012	44.1%	111,088	5.3%	2,097,394	100.0%
	Facial tissue, other than towelling, napkin and toilet	114,156	34.4%	200,922	60.6%	16,459	5.0%	331,537	100.0%
	Napkin stock, Industrial and resale	242,105	34.6%	369,733	52.9%	87,184	12.5%	699,022	100.0%
	Towelling, excluding wiper stock, Industrial and household	886,086	47.7%	752,410	40.5%	219,344	11.8%	1,857,840	100.0%
	Wiper stock, regular, facial, & wadding	[D]		[D]		--	0.0%	155,678	100.0%
	Sanitary napkin stock wadding & other sanitary stock	[D]		[D]		--	0.0%	149,601	100.0%
	Tissue paper, excluding sanitary & thin	18,205	11.4%	97,278	60.8%	44,462	27.8%	159,945	100.0%

(Cont.)

Table 2.D-1. (cont.)
1989 Shipments of Paper and Board, by Type of Producer
 (Quantity in short tons)

Product Description	Producers of Bleached Kraft Pulp [a]		Consumers of Bleached Kraft Pulp [b]		Other Mills [c]		TOTAL	
	Shipments	Percent	Shipments	Percent	Shipments	Percent	Shipments	Percent
Paperboard	8,560,685	22.5%	1,718,463	4.5%	27,768,165	73.0%	38,047,313	100.0%
Solid woodpulp furnish paperboard	8,203,432	28.4%	1,085,697	3.8%	19,610,275	67.9%	28,899,404	100.0%
Unbleached kraft packaging and industrial converting paperboard	2,751,864	14.6%	[D]		[D]		18,794,872	100.0%
Unbleached linerboard	2,647,697	15.3%	[D]		[D]		17,356,067	100.0%
Tube, can, and drum paperboard	[D]		[D]		[D]		59,869	100.0%
Other	[D]		[D]		[D]		1,378,936	100.0%
Bleached packaging and industrial converting paperboard	4,886,250	99.6%	19,385	0.4%	--	0.0%	4,905,635	100.0%
Linerboard	445,476	100.0%	--	0.0%	--	0.0%	445,476	100.0%
Folding carton type board	2,211,352	100.0%	[D]		[D]		2,211,665	100.0%
Milk carton board	1,143,115	100.0%	--	0.0%	--	0.0%	1,143,115	100.0%
Heavyweight cup & round neeted food contain	425,682	100.0%	--	0.0%	--	0.0%	425,682	100.0%
Plate, dish, and tray stock	319,583	99.1%	[D]		[D]		322,567	100.0%
Bleached paperboard for misc. packaging	73,353	100.0%	--	0.0%	--	0.0%	73,353	100.0%
Other solid bleached board	267,689	94.3%	[D]		[D]		283,777	100.0%
Semichemical paperboard, including corrugating medium and other uses	565,318	10.9%	[D]		[D]		5,198,897	100.0%
Recycled paperboard	357,253	3.9%	621,061	6.9%	8,067,337	89.2%	9,045,651	100.0%
Shipping containerboard	357,253	11.6%	109,593	3.5%	2,623,212	84.9%	3,090,058	100.0%
Folding carton	--	0.0%	343,127	13.4%	2,221,333	86.6%	2,564,460	100.0%
Setup	--	0.0%	[D]		[D]		291,873	100.0%
Packaging and industrial converting	--	0.0%	[D]		[D]		3,099,260	100.0%
Wet machine board, including binder's board and shoe board	--	0.0%	[D]		[D]		102,258	100.0%

(Cont.)

Table 2.D-1. (cont.)
1989 Shipments of Paper and Board, by Type of Producer
 (Quantity in short tons)

Product Description	Producers of Bleached Kraft Pulp [a]		Consumers of Bleached Kraft Pulp [b]		Other Mills [c]		TOTAL	
	Shipments	Percent	Shipments	Percent	Shipments	Percent	Shipments	Percent
Construction Paper and Board	--	0.0%	67,371	2.6%	2,478,992	97.4%	2,546,363	100.0%
Construction paper	--	0.0%	[D]		[D]		334,997	100.0%
Structural insulation board:								
Insulating board	--	0.0%	--	0.0%	517,634	100.0%	517,634	100.0%
Hardboard	--	0.0%	--	0.0%	1,693,732	100.0%	1,693,732	100.0%

-- Represents zero. [D] Data withheld by Census Bureau to avoid disclosing figures for individual companies.

[a] Mills that produce bleached kraft pulp.

[b] Mills that consume bleached kraft pulp (market pulp).

[c] Mills that neither produce nor consume bleached kraft pulp.

Source: U.S. Department of Commerce, Bureau of the Census, 1989 Pulp, Paper, and Board Survey (MA26A), Special Tabulation for Bleached Pulp.

APPENDIX 3.A

OVERVIEW OF THE PULPING PROCESS

APPENDIX 3.A

OVERVIEW OF THE PULPING PROCESS

This appendix presents a brief overview of the production processes used to manufacture pulps. It illustrates the integrated nature of the process with respect to impacts of raw material selection and processing on final products.

Raw Materials

There are four major types of fiber used for papermaking:

- a. Hardwood
- b. Softwood
- c. Secondary fibers (recycled fiber)
- d. Nonwood fibers

Pulps produced from hardwood trees (oak, maple, birch, beech, etc.) contain relatively short fibers, typically one to 2.5 mm in length, making them less desirable than pulps produced from softwood trees from the standpoint of strength. Pulps produced from softwood trees (pine, spruce, hemlock, etc.) contain fibers from about three to more than 5 mm in length. Many papers are made from blends of hardwood and softwood pulps to take advantage of the strength of the softwood pulp and the dense hardwood pulp. In the U.S., about twice as much softwood pulp is produced compared to hardwood pulp.

Secondary fibers are derived from recycle of paper and paperboard. Depending upon waste paper segregation and processing, secondary fibers can be converted into low to high grades of finished paper. Examples of nonwood fibers include cotton, sugar cane waste called bagasse, bamboo, and wheat straw. Nonwood fibers are often converted to low volume, specialty grades of paper. Certain plastics and latexes are also used for specialty papermaking.

Pulping Processes

In 1988, the U.S. pulp and paper industry produced about 61 million tons of wood pulp by the following processes:

Bleached Sulfate (Kraft)	43.0%
Unbleached Sulfate	35.4%
Semichemical	7.1%
Groundwood and Refiner	5.0%
Thermomechanical	4.7%

Total Sulfit	2.6 %
Dissolving and Special Alpha	2.2 %
Total	100.0 %

The principal distinguishing characteristics and the major products associated with each pulping process are briefly reviewed below.

Mechanical Pulp - Stone Groundwood

Stone groundwood pulp is produced by forcing logs against a grindstone by mechanical pressure. Nearly all of the log is converted into a low grade pulp used principally for newsprint and other products where permanence is not an important factor. Lignin, which binds wood fibers together, imparts color to pulp and causes yellowing of paper, is not removed in this process. Other products made from stone groundwood pulp include towels, inexpensive writing paper and molded products such as egg cartons.

For newsprint production, groundwood pulp is usually blended with about 20 % chemical pulp for added strength. Groundwood pulp is usually not bleached, or, if bleached, not to a high degree of brightness. The frayed and broken fibers obtained from groundwood pulping are quick to absorb printing inks and are thus suitable for high speed printing.

Refiner Mechanical Pulp

In this process wood chips are passed through double-disc refiners where the fibers are mechanically separated as opposed to grinding on a stone. The fibers are frayed for better bonding, but are not chopped indiscriminately as in the groundwood process. Consequently, refiner mechanical pulp is stronger than groundwood pulp and more suitable for certain uses where strength is an important factor.

Thermomechanical Pulp (TMP)

Thermomechanical pulp is produced by preheating wood chips with steam prior to refining as described above. The heat acts to soften the lignin which binds the wood fibers together, allowing for separating fibers which are nearly intact. This results in a stronger pulp than obtainable by the groundwood process and minimizes the need for more expensive chemical pulp in newsprint production.

Semichemical Pulp

In this process, wood chips are processed in a relatively mild chemical solution prior to mechanical refining for fiber separation. The chemical solution is usually a neutral sodium sulfite/sodium carbonate liquor which acts to soften the lignin and promote fiber separation. Hence, the name neutral sulfite semichemical (NSSC) pulp. The yield of semichemical pulping is dependant on the specific process used, and may be in the range of 65 to 85 percent. Most semichemical pulps are not bleached and are used for corrugated board, newsprint and specialty boards. Bleached NSSC pulps can be used to make writing and bond papers, offset papers, tissue and toweling.

Chemical Pulps

Chemical pulp production for 1987 was nearly 50 million tons. The breakdown by pulping process and bleaching practice is summarized below:

Bleached Kraft	51.0 %
Unbleached Kraft	43.0 %
Bleached Sulfite	2.7 %
Unbleached Sulfite	0.3 %
Specialty Grades	3.0 %
Total	100.0 %

The dominance of the kraft pulping process is apparent. The kraft process accounted for about 94 % of chemical pulp production in 1987 vs. 83 % in 1964. About 54 % of kraft pulp was bleached in 1987, vs. 40 % in 1964.

In the kraft and sulfite pulping processes, hardwood or softwood chips are cooked in chemical solutions under heat and pressure to dissolve the lignin that binds cellulose wood fibers together. The kraft or "sulfate" process uses an alkaline solution of primarily sodium sulfide (Na_2S) and sodium hydroxide (NaOH). Sodium sulfate (Na_2SO_4) and lime (CaO) are used to replenish the pulping liquor as part of the chemical and energy recovery operations associated with the process. The yield of the kraft process is about 50 percent.

The sulfite process is an acid process in which chips are cooked in a liquor consisting of calcium, magnesium, sodium or ammonia salts of sulfurous acid. The distinguishing characteristics of the kraft and sulfite pulping processes and kraft and sulfite pulps are presented in Table 3.A.1.

Table 3.A.1.

Comparison of Kraft and Sulfite Pulping Processes		
	Kraft Process	Sulfite Process
Cellulosic Raw Material	Almost any kind of wood, soft or hard	Usually coniferous, must be of good color and free of certain hydroxy phenolic compounds
Principal Reaction in Digester	Hydrolysis of lignins to alcohols and acids; mercaptans are formed	Sulfonation and solubization of lignin with bisulfite; hydrolytic splitting of the cellulose-lignin
Composition of Cooking Liquor	12.5% solution NaOH, Na ₂ S and Na ₂ CO ₃	7% by weight SO ₂ , of which 4.5% is present as sulfurous acid, and 2.5% Ca or Mg (HSO ₃) ₂
Cooking Conditions	2-5 hours at 340-350 F and 100-135 psi	6-12 hours at 257-320 F and 90-110 psi
Chemical Recovery	Most of process is devoted to recovery of cooking chemicals, with energy recovery from burning organic matter dissolved in liquor. Chemical losses are replenished with salt cake, Na ₂ SO ₄	SO ₂ relief gas recovered; Mg liquor recovered after wood digestion and washing
Pulp Characteristics	Brown color; difficult to bleach; strong fibers; resistant to mechanical refining	Dull white color; easily bleached; fibers weaker than kraft fibers
Typical Paper Products	Strong brown bag and wrapping; multiwall gabs; gumming paper; building paper; white papers from bleached kraft; paperboards for cartons, containers and corrugated board	Book paper, bread wrap, sanitary tissue