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RECYCLING AND DEINKING OF RECOVERED PAPER

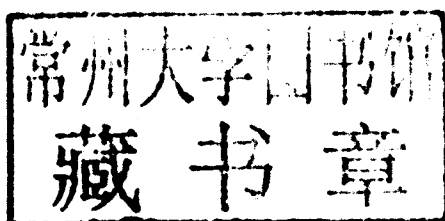
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Recycling and Deinking of Recovered Paper

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Preface

Paper recycling has been practised for many decades in numerous countries around the world. The paper industry is among those that almost perfectly meet the expectations of society for the sustainability of their raw material base, the environmental compatibility of their processes and the recyclability of their products, and it has done so for a long time. In particular, recyclability has dramatically improved the image of the paper industry in the past few years. Recycling of paper and paper-related products is very important for sustainable economic growth. It helps save landfill space and costs, reduces the energy requirements for paper manufacturing and extends the supply of fibre. Paper recycling reduces consumption of precious natural resources (wood, water, minerals and fossil fuels). It is an important service to society and is profitable. Rigorous scientific research supports the benefits of recycled paper, and government agencies, environmental groups and many other large purchasers have adopted policies mandating its use. Recycling technologies have improved in recent years through advances in pulping, flotation deinking and cleaning/screening. This has resulted in the quality of paper made from secondary fibres approaching that of virgin paper. However, the process is much more eco-friendly than the virgin-papermaking process. By using recycled paper, companies can take a significant step towards reducing their overall environmental impacts. Most of the paper producers throughout the world are increasing their use of recycled fibres for paper products. The percentage of recycled fibre in almost every grade of paper and board, particularly in printing and writing papers, has more than doubled in the past decade; in the next 10–15 years it is expected to triple or quadruple. Earlier, paper was recycled mainly because it made economic sense to do so, whereas now it has been driven more by a collective environmental mandate of sorts. The marketplace for secondary pulps and papers continues to develop and mature. Deinked pulp has become a principal raw material for many papermaking operations around the world. Many newsprint and tissue grades commonly contain 100% deinked pulp, which is also a substantial furnish constituent of other grades, such as lightweight coated for offset, and printing and writing papers for office and home use. The scientific and technical advances in recycling and deinking are discussed in this book.

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1 Introduction*

1.1 The Paper and Paperboard Industry in the Global Market

The pulp and paper industry is one of the largest industries in the world. It is dominated by North American, Northern European and East Asian countries. Latin America and Australasia also have significant pulp and paper industries. Over the next few years, it is expected that both India and China will become the key countries in the industry's growth. World production of paper and paperboard is around 390 million tonnes and is expected to reach 490 million tonnes by 2020. In 2009, total global consumption of paper was 371 million tonnes (Figure 1.1). In North America, total paper consumption declined 24% between 2006 and 2009.

Growth is speedy in Asia; it accounts for almost 40% total world paper and paperboard production whereas the European Union (EU) and North America account for about one quarter each. The profitability of pulp and paper industry has been weak on the global level in recent years. Excess capacity has led to falling product prices that have, with the impact of rising production costs, eroded the industry's profitability globally.

Consumption of paper and paperboard per person varies significantly from country to country. One person uses about 60kg of paper a year on average; the extremes are 265kg for each US resident and some 7kg for each African. In the heavily populated areas of Asia, only around 40kg of paper per person is used. This means that Asian consumption will continue to grow intensely in the coming years if developments there follow the example of the West. In Finland, consumption of paper and paperboard per person is about 194kg. Although India's population is about 7% of the world's population, it consumes barely 2% of the global paper output with consumption per person at only 9kg against a global average of 55kg, 65kg in China and 215kg in Japan. Rapid growth in Asian paper production in recent years has increased the region's self-sufficiency, lessening the export opportunities available to both Europeans and Americans. Moreover, Asian paper has started to enter Western markets – from China in particular. Global contest has increased noticeably as the new entrants's cost level is considerably lower than in competing Western countries.

The European industry has been dismantling overcapacity by shutting down mills that do not make any profit. In all, over 5% of the production volume in Europe has been closed down in the past few years. Globally speaking, the products of the forest industry are primarily consumed in their country of production, so it can be considered a domestic-market industry. The largest trade flows are between the countries of

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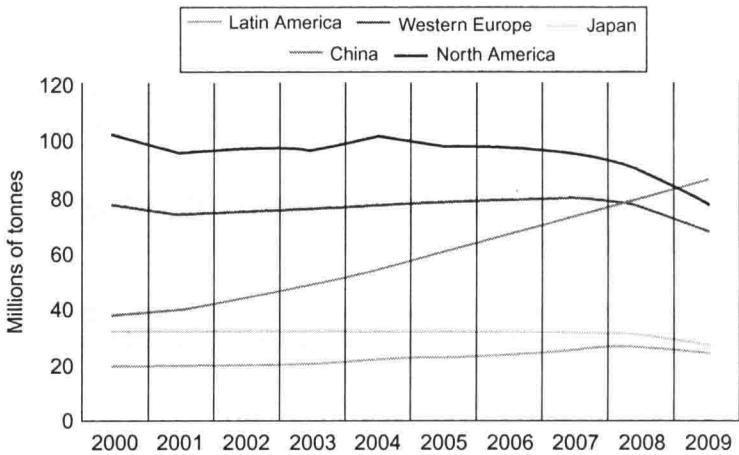


Figure 1.1 Total paper and paperboard consumption; North America versus other selected regions.

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Central Europe and between the Nordic countries and Central Europe. Furthermore, a lot of Canadian paper is exported to the USA. In Asia, Korea is a significant exporter. The most significant intercontinental trade flows are directed from Europe and North America to Asia, from Europe to North America as well as from North America to South America. The profitability of paper industry companies has been weak overall in the recent years. Overcapacity has led to falling prices and this, coupled with rising production costs, is eating into the sector's profitability.

1.2 General Aspects of Paper Recycling

Paper recycling in an increasingly environmentally conscious world is gaining importance (Anon, 2004a,b, 2005a,b; Bajpai, 2006; DIPP, 2011; Edinger, 2004; Francois, 2004; Friberg & Brelsford, 2002; Friberg et al., 2004; Raivio, 2006; Robbins, 2003; Rooks, 2003; Selke, 2004). Recycled fibres play a very important role today in the global paper industry as a substitute for virgin pulps. Paper recovery rates continue to increase each year in North America and Europe (with the exception of 2009–2010 in Europe owing to a dip in production during the economic downturn). In March, the American Forest & Paper Association launched its Better Practices Better Planet 2020 initiative, establishing an ambitious goal of 70% paper recovery by 2020 (the recovery rate was 63.5% in 2010) (Jourdan, 2011). Much increase in paper recovery can be attributed to the increase in easy residential and commercial recycling through single-stream recovery systems, as 87% of Americans now have access to curbside or drop-off paper recycling programmes. Figure 1.2 shows the US and Canadian recovery rates.

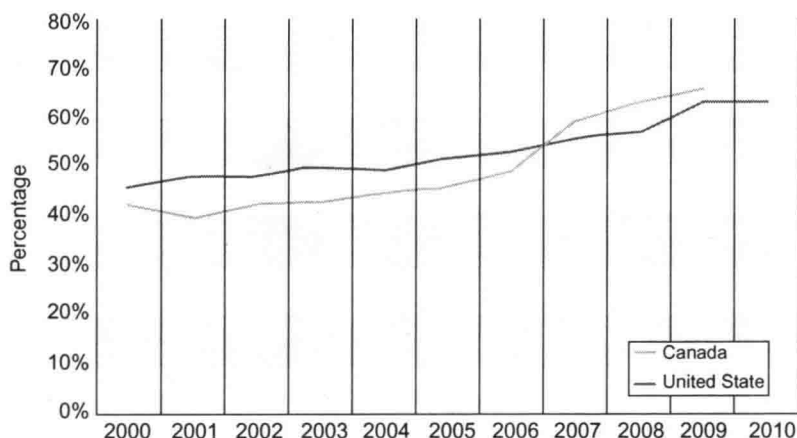


Figure 1.2 US and Canadian recovery rates.

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The recycling rate in Europe reached 70.4% in 2011 (Figure 1.3). The total amount of paper collected and recycled in the paper sector remains stable at 58 million tonnes, the same as in the previous years. However, this is an increase of 18 million tonnes since 1998, the base year for the first voluntary commitment the paper value chain set itself for increasing recycling in Europe. A net volume of 9.2 million tonnes (or 15.9%) of the total 58 million tonnes was imported for recycling by third countries outside the commitment region of the EU-27 plus Norway and Switzerland. Thirteen European countries exceed the 70% recycling rate, 12 European countries are below 60%. Figure 1.4 shows recycling rate in world regions in 2010. Europe is the leader in paper recycling.

Exports of recovered fibre from the USA to Asia have grown rapidly, representing a nearly three-fold increase since 2002. These exports are primarily destined for China. In 2009, approximately 36% of fibre recovered in the USA was exported to Asia.

With rapid developments in deinking processes for the reuse of secondary fibres being made, the recycling process is becoming increasingly efficient. The quality of paper made from secondary fibres is approaching that of virgin paper. Its manufacture is much more eco-friendly than that of virgin paper. The main drivers leading to increased paper recycling have traditionally been economic, that is limited availability and, hence, higher costs of virgin wood fibres. However, during the past decade, environmental and ecological concerns have become increasingly important (Stawicki & Barry, 2009). As the paper industry strives towards full sustainability, recycling becomes an increasingly important component of the supply chain.

Cost competition and the legal requirements in many countries mainly promote the use of recovered paper (Putz, 2006). The effect of environmentalists through 'green' movements and the level of acceptance in the market of paper made from recycled fibres are additional driving forces that vary by country. Recovered paper use is an environmentally friendly issue according to the recycled fibre processing

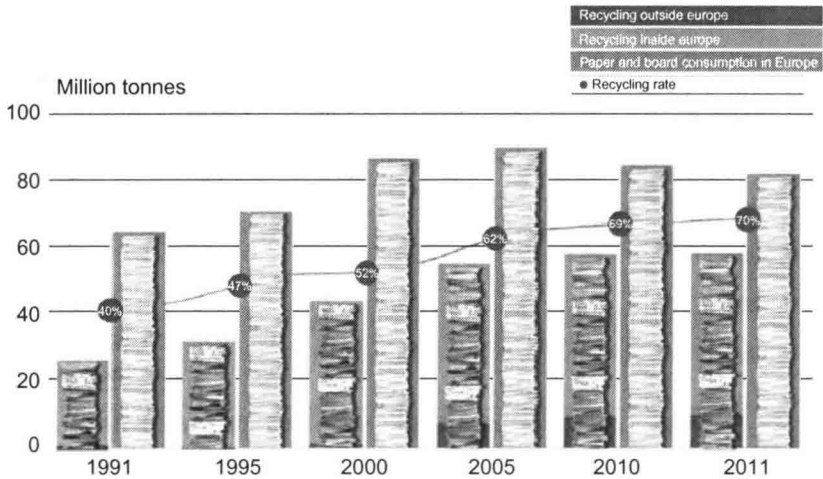


Figure 1.3 European paper recycling (1991–2011).

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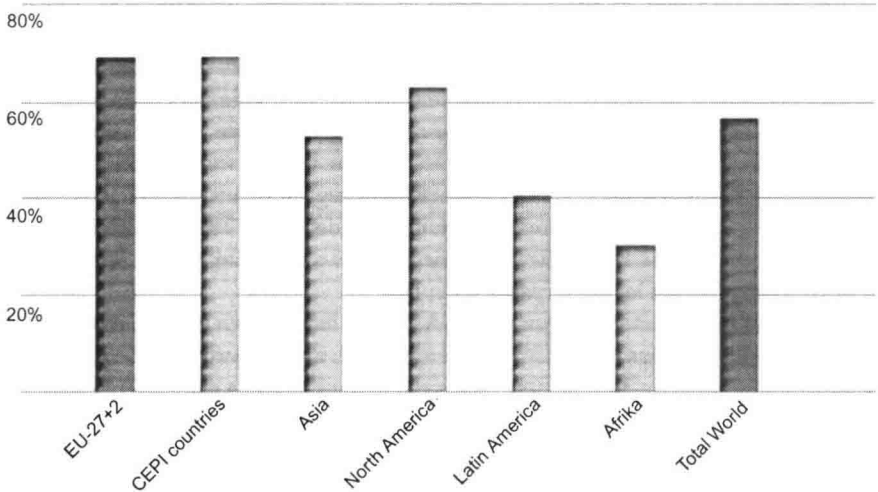


Figure 1.4 Recycling rates in world regions in 2010.

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paper industry, environmentalists, governmental authorities and often even the marketplace. Recycling preserves forest resources and energy used for production of mechanical pulps for paper manufacturing. Moreover, recovery and recycling of used paper products avoids landfilling. The processing of recycled products requires comparatively little fresh water per tonne of paper produced. However, the solid waste rejects and sludge from recovered paper processing mills typically

present a problem. The rate of formation of such residues is between 5% and 40%, depending on the recovered paper grade processed and the paper grade produced. The average rate of rejects and sludges totals about 15%, calculated from the recovered paper input on an air-dried basis. Because landfilling of organic matter has no future in several countries, most organic waste requires burning to reduce its volume. Effective, clean incineration technologies are available that control flue gas emissions, and the heat content of the residues and sludges contributes to self-supporting incineration. The final waste can be used as raw materials in other industries or can be discarded. An increasing volume of rejects and sludges can be used in brick works, the cement industry and for other purposes.

Most of the paper producers throughout the world are increasing their use of recycled fibres for paper products. The percentages of recycled fibre in almost every grade of paper and boards, and particularly in printing and writing papers, has more than doubled in the past decade. In the next 10–15 years, it is expected to triple or quadruple. Earlier, paper recycling was done mainly because it made economical sense to do so, whereas now it has been driven more by a collective environmental mandate of sorts. The marketplace for secondary pulps and papers continues to develop and mature. This huge secondary paper undertaking is primarily aimed at reducing volumes of waste paper in the world's growing landfill sites.

Paper recycling has become an increasingly important industry. Every year the percentage of paper that is recycled increases compared with the percentage that ends up in landfills. The paper recycling industry has seen marked changes over the past decade. Previously, recycled fibre was mostly used to produce products of lower quality. Today, because of new technology, recycled fibre can sometimes be used nearly interchangeably with new fibre to make even the highest quality grades of paper.

The larger quantities of waste paper available have helped to reduce the costs of recycling and provide a greater array of recycled paper and paper products. The process begins with collection, which is still one of the most expensive aspects of paper recycling. Besides collecting, the collection process involves sorting the paper into categories, baling and transporting the paper to a facility that will manufacture the waste paper into pulp. The first step at one of the repulping facilities is put the paper into large vats where it is soaked, reducing the paper into fibres. This process is known as repulping. When ink starts to separate from the fibres, chemicals are added to prevent the ink from reattaching to the paper fibres. The ink is then removed from the pulp in a deinking system, which is a series of screens that remove ink and additives. Then the pulp is cleaned several times with heat and chemicals, which removes additional ink. The pulp then enters a flotation device, where a chemical mixture containing calcium soap is introduced. Air bubbles form in this pulp. The chemical mixture causes any remaining ink to float to the surface where it can be skimmed away. After the deinking process, the pulp is ready to be manufactured into paper and related products in a similar manner to that by which paper is produced from wood pulp.

Some paper and board grades produced can use recycled fibres exclusively. This can include corrugating medium and test liner, or newsprint. Other grades use blends of recycled and virgin fibres. Europe is the largest producer of writing and printing

grades whereas North America is the largest producer of newsprint (more exactly, Canada is the world's largest producer), tissue, container board and board.

According to Kenny (2005), 49% of fibrous raw material used in the paper industry is derived from recovered materials. Nearly 56% of paper products are being recycled, with a potential maximum of 81%. The remaining 19% represents unrecoverable paper and board. Sustainable development seeks to reach the maximum paper recyclability by improving knowledge of fibre flows. Recovered paper is commercially circulated throughout the world in forms of packaging and paper products. The Asian economy is rapidly expanding, with increased consumption of paper products. North American paper consumption is slowing or reversing. European consumption is growing slowly, but slightly faster in Eastern Europe. Asia is investing in increased paper-making capacity as well as importing paper products from the USA, but its reliance on recovered paper will increase. Collection of paper products is rising in Europe at a higher rate than consumption, except in Germany. Worldwide circulation of recovered paper will encourage collectors to improve quality, levelling standards and organising separate collection channels with a more consistent approach. New technology will help reduce paper loss during production and will encourage development of products based on recycled materials. The Western world can still increase collection rates, and developing economies will develop their own recovered paper sources.

Moore (2004) has reported that more than 80% of paper mills in the USA use recovered paper to make many of their products, and 200 mills in the USA use recovered paper exclusively. Of the paper currently recovered in the USA, 95% is recycled into new paper products, with the balance used in other applications. Over the past 20 years, the American Forest and Paper Association (AF&PA) has made recovered paper an integral part of the paper and paperboard industry (AF&PA, 2010). More than 38% of all the raw material used to make new paper comes from recovered paper. In addition, the paper industry in the USA has coupled efforts to improve its recycling capabilities with initiatives aimed at improving access to recovered paper. These efforts have increased the amount of paper kept from the waste stream and put into new products and packaging.

Today, most recovered paper is used as a raw material in packaging grades such as carton board and paperboard, because the manufacture of these grades does not typically involve deinking and/or bleaching (Jaakko Poyry, 2009). Therefore, the processing is generally less costly and may also have fewer environmental impacts than when deinking and bleaching are required. Over 90% of recovered paper in the world is used in grades other than for printing and writing, such as newsprint, tissue, container boards and other packaging or board products. Approximately 6% of the global recovered paper supply is used in printing and writing grades, and this percentage is forecast to increase only slightly by 2025. Most of the forecasted increase is in container boards, carton boards and tissue paper (Jaakko Poyry, 2009).

The distance between the recovered fibre source (usually areas of large population density) and the mill site is a key factor to consider when using recovered paper as a raw material. It is typically more economical to have short transportation distances to make the life cycle of the paper more efficient, but also to minimize the carbon footprint of

transporting raw materials. In graphics applications, customers often require paper with good printing qualities and paper that will run well, without breaking, on high-speed printing presses. These quality requirements often require the use of fresh wood fibre as a raw material, instead of deinked pulp from recovered paper. Sheet strength and printing quality can vary tremendously depending on the type and quality of deinked pulp used. Furthermore, poor runability on printing presses can lead to higher waste generation.

Clearly, the act of recycling paper is beneficial for the environment, but the responsible use of recovered paper as a raw material to make new products should take into account economic and environmental consequences. Sustainable use of recycled fibre means using it in the right locations and in the right paper grades. As a guideline, the United States Environmental Protection Agency (US EPA) has recommended significantly different levels of total recovered fibre in certain paper grades, ranging from 10% for printing and writing grades to 100% for newsprint and packaging (US EPA, 2007).

1.3 Benefits of Recycling

Recycling of waste paper has several benefits, both for humans and the earth (Bajpai, 2006; Putz, 2006; Sappi, 2011).

- The process of recycling protects the environment. Using recycled paper to make new paper reduces the number of trees that are cut down, conserving natural resources. Every tonne of recycled fibre saves an average of 17 trees plus related pulping energy. In some instances, recycling services are cheaper than trash-disposal services. Recycling paper saves landfill space and reduces the amount of pollution in the air from incineration. Businesses can promote a positive company and community image by starting and maintaining a paper-recycling programme. Parents can promote a clean environment and a healthy lifestyle to their children by teaching them about the benefits of recycling paper.
- By using waste paper to produce new paper, disposal problems are reduced. The savings are at least 30,000 L of water, 3000–4000 kW h of electricity and 95% of air pollution for every tonne of paper used for recycling. Also, 3 yd³ of landfill space are saved. And in many cases, recovering paper for recycling can save communities money that they would otherwise have to spend for disposal.
- Compared with virgin paper, producing recycled paper involves between 28% and 70% less energy consumption. Also, less water is used. This is because most of the energy used in papermaking is the pulping needed to turn wood into paper.
- Recycled paper produces fewer polluting emissions to air and water. Recycled paper is not usually re-bleached and, when it is, oxygen rather than chlorine is usually used. This reduces the amount of dioxins that are released into the environment as a by-product of the chlorine bleaching processes.
- High-grade papers can be recycled several times, providing environmental savings every time.
- Producing recycled paper actually generates between 20% and 50% fewer carbon dioxide emissions than paper produced from virgin fibres.
- Because used paper is usually collected fairly near to recycling plants, manufacturing recycled paper reduces transport and carbon dioxide emissions.

- Recycling paper reduces the volume of waste while helping to boost the local economy through the collection and sorting of waste paper.
- Waste paper pulp requires less refining than virgin pulp and may be co-refined with hardwood pulp or combined hardwood/softwood pulps without significant damage
- The kinds of deinked pulp suitable for use in printing papers usually impart special properties to the finished papers compared with papers made from wood pulp, such as increased opacity, less curling tendency, less fuzziness, better formation, etc.
- Not all effects of recycling paper are positive ones. Recycling mills are known for producing sludge, which is the runoff that includes ink, adhesives and other unusable material removed from the usable fibre. But according to Conservatree, the materials in sludge would still end up in landfills or incinerator emissions if the paper was not recycled, and recycling mills have developed environmentally controlled methods of handling sludge. In some cases, paper recycling has real environmental and economic benefits and some cases it does not. Depending on the circumstances, paper recycling may use more resources than it saves, or cost too much to be of much benefit, depending on the circumstances. A lot depends upon the type of recovered paper being used and the type of recycled paper being produced. Because wood and recovered paper are excellent fibre sources and because advanced recycling technology allows papermakers to use recycled fibre in new ways, the possibilities for using recycled fibre in today's paper products are greater than ever. About 38% of the raw material used in US paper mills is recovered paper. In many cases, the quality of recycled paper products is very close to the quality of those made from new fibre. Paper manufacturers must choose the raw materials best suited to make their products. In some cases, new wood fibre is the better choice; in others, recycled fibre is preferable. It is up to the manufacturer to decide how to use the fewest possible resources to make quality products that meet consumers' needs.

1.4 Statistics

The importance of recovered paper as a raw material in the paper industry has increased markedly during the past decade. In 2011, paper recovery increased by 1.2 million tonnes, raising the US paper recovery rate to a record high 66.8% (www.paperrecycles.org), which is an increase from 63.5% in 2010 and 33.5% in 1990, the base year from which the industry's original 40% recovery goal was benchmarked (Table 1.1). The key figures show that the collected recycling paper increased from 26 million tonnes in 1991 to 57 million tonnes in 2011. Utilisation rose from approximately 26 million tonnes to 48 million tonnes. From 2000 to 2011 the exports to outside the Confederation of European Paper Industries (CEPI) increased from 3.5 million tonnes to 10.2 million tonnes, the imports from outside CEPI doubled from 753,000 tonnes in 2000 to 1.4 million tonnes in 2011. The utilisation rate – defined as percentage of paper for recycling utilisation compared with the total paper and board production – climbed from 39.1% in 1991 to 51% in 2011. In Europe at the same time, the recycling rate – the utilisation of paper for recycling and net trade for paper of recycling, compared with paper and board consumption – increased from 40% to 70%.

Data for the year 2011 indicates that 30% of the paper and paperboard recovered in the US went to produce containerboard and 11% went to produce boxboard,

Table 1.1 Paper and Paperboard Recovery Rate

Year	Recovery Rate (%)
1990	33.5
1991	36.7
1992	38.5
1993	38.7
1994	41.5
1995	44.0
1996	45.6
1997	44.2
1998	44.6
1999	44.5
2000	46.0
2001	48.3
2002	48.2
2003	50.3
2004	49.3
2005	51.5
2006	53.0
2007	56.0
2008	57.7
2009	63.6
2010	63.5
2011	66.8
2012	65.1

Source: Based on www.paperrecycles.org

Table 1.2 Uses of Recovered Paper

Packaging Type	Share of Total (%)
Newsprint	3.0
Tissue	8.0
Containerboard	31
Boxboard	12.0
Other	5.0
Net exports	41.0
Total	100

Source: Based on www.paperrecycles.org

which includes folding boxes and gypsum wallboard facings (Table 1.2). Exports of recovered paper to China and other nations absorbed 42% of the paper collected for recycling in the US in 2011. Although new supply of printing-writing and related papers declined by more than 5% in 2011, printing-writing paper recovery contracted just 1.2%. The recovery rate for printing-writing papers consequently