wbcsd forest solutions

FACTS & TRENDS

Fresh & Recycled Fiber Complementarity

Technical content by
ncasi

CONTENTS

CONTEXT

Together with its members, the World Business Council for Sustainable Development has launched its Action2020 program to develop and deliver business solutions that can help society get on track to achieve the vision of having 9 billion people, all living well, within the limits of the planet, by 2050 (WBCSD 2014a). Sustainable Lifestyles is one of Action2020's priority areas and the societal must-have is described as:

Enable and motivate consumers for sustainable lifestyles

By 2020, people will be able to enjoy a better quality of life within social and planetary boundaries through the provision of more sustainable products and services and will be motivated to move towards more sustainable consumption patterns:

✓ Create transparency on the footprint of consumption: A clear understanding of the key impacts across the full value chain that products have on social and planetary boundaries, from a country, consumer and company perspective,

✓ Provide more sustainable products and services: Products and services with improved environmental and societal impacts, which also enable people to improve their quality of life,

✓ Empower and motivate consumers: Reliable and actionable information on products and services as well as a motivating societal environment to drive consumers towards more sustainable consumption patterns.

How does this relate to the use of fresh & recycled fiber?

Demand for wood and fiber is expected to increase for the foreseeable future. Using natural resources responsibly and transparently is key to meeting this demand. Recovery and recycling is an integral part of using resources efficiently, reducing consumption footprints, providing sustainable products and thereby contributing to creating more sustainable lifestyles.

Forests provide us with a renewable and highly recyclable raw material – wood. Fiber obtained from wood is used to make paper and other products. Given resource constraints, the recovery and recycling of wood and paper products are essential to make a resource-efficient, quasi-circular economy a reality.

Decisions about the purchase and use of wood, fresh and recycled fiber can have wide-ranging consequences on environmental, social and economic values of forests and other natural resources. Making informed choices is imperative for all businesses in building and retaining consumer confidence in their product offerings, including the use of paper, packaging and other fiber based materials.

With this Facts & Trends report the WBCSD Forest Solutions Group aims to demonstrate the complementarity of fresh and recycled fiber for the sustainable supply of renewable raw material and products, outline environmental trade-offs between choosing between fresh and recycled fiber and emphasize how to maximize the value of each harvested tree.

KEY MESSAGES

Why are fresh and recycled fiber complementary?

(see sections 3 and 6 for detail.)

- Fresh fiber and recycled fiber are part of a single integrated wood fiber system, because

✓ Recycled fiber would not exist if fresh fiber were not harvested,

✓ There are limits to the amounts of used paper and paperboard that can be recovered,

✓ Some fiber is lost during recovery and recycling processes,

✓ Fiber degrades with multiple uses, eventually becoming unsuitable for use in paper and paperboard,

✓ Fresh fiber is essential to meet some quality and product requirements.

- More than 50% of papermaking fiber comes from recovered fiber. Quite simply, societal demands for paper and paperboard products could not be met without both fresh and recycled fiber. While continued growth in paper recovery will offset some of the future demand for fiber, fresh fiber production will also have to increase to provide the amounts of fiber needed.

How to maximize the societal value of each harvested tree?

(see section 4 for detail.)

- The most eco-efficient use of wood fiber for paper and paperboard is within a cascading system. In a simple cascading system, fresh fiber is removed from the forest and used to make wood or paper products which are recovered after use and the recycled fibers are reused in paper and paperboard manufacturing until they are unsuitable, at which point they are burned for energy, displacing fossil fuel. In reality, cascading that occurs within the wood fiber system is more complex. For instance, some papermaking fiber comes directly from the forest, some comes from sawmills as a by-product and some comes from recovery and recycling of paper.

What are the environmental trade-offs between fresh & recycled fiber?

(see sections 5 and 6 for detail.)

- Mills producing fresh fiber use different processes than mills using recycled fiber. As a result, the releases to the environment differ. Recycled fiber production can result in higher or lower releases to the environment than fresh fiber production depending on the type of release, the product being manufactured and the fuel being used.
- Studies generally agree that recycling has lower environmental impacts than landfill disposal, but there is less agreement on the environmental benefits of recycling compared to burning for energy, with the results depending on a number of scenario-specific factors. Within the context of an efficient cascading system, however, where recyclable fibers are diverted from disposal, burning for energy would not act as an alternative to recycling, but as an eco-efficient means of gaining value from fibers that have no higher-value use.
- Because fresh and recycled fibers are part of a single complex system, it is very difficult to compare the environmental attributes of recycled and fresh fibers. The results of studies comparing fresh and recycled fibers are heavily influenced by decisions on how to split the single integrated system into separate fresh fiber and recycle fiber systems to allow the comparison.

What does the future of fresh & recycled fiber look like?

(see section 9 for detail.)

- In developed countries, the recovery of paper and paperboard is approaching the maximum that can be practically achieved. The recovery rate is approaching 70% in the United States, is slightly above 70% in Europe and is approaching 80% in Japan.
- The amounts of recovered fiber being used in newsprint, containers and packaging are already at very high levels. For instance, utilization rates for newsprint and case materials (a.k.a. containerboard) exceed 90% in Europe. Further increases in the use of recovered fiber will require more to be used in grades that have quality requirements that can be difficult to meet with recovered fiber.
- Declining production of some grades of paper means that the amounts of recovered fiber obtained from these grades will also decline.
- The use of recovered fiber is only one of many factors to consider in a sustainable procurement program.

INTRODUCTION

Paper and paperboard products provide a range of important functions, ranging from personal hygiene and communication to protecting commercial goods during shipment. While paper and paperboard are composed mainly of wood fibers which come from a renewable resource, namely trees, these fibers can be reused many times before they become unsuitable as a raw material for paper and paperboard production. Fresh fiber and recycled fiber, therefore, must be understood as parts of a single integrated wood fiber system. Recycled fiber would not exist if fresh fiber were not harvested, processed and placed into the wood fiber system. Yet, with more than half of the industry's fiber coming from recovered paper, the industry would be unable to meet the demand for its products without recycled fiber. Both are required.

In this report, the complementarity of fresh and recycle fiber is examined, yielding insights into the functions of different types of fibers, the resource and environmental impacts of recycling, and the challenges to increasing recycling rates.

Takeaways
Renewability & recyclability

- Fresh and recycled fiber are part of a single integrated wood fiber system.
- Fiber is obtained from wood, which is a renewable raw material used to produce a wide range of everyday products.
- Wood and fiber are widely recyclable.
- Recycled fiber would not exist without harvesting fresh fiber.

Global paper & paper packaging production & flow of fiber

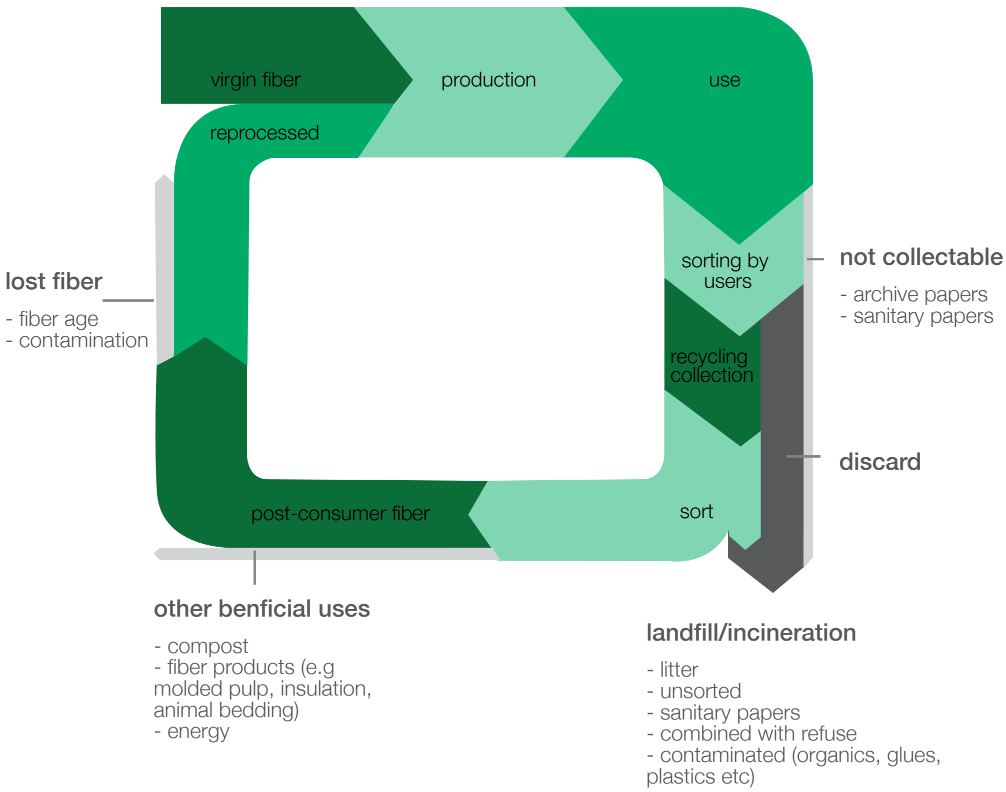


Figure 1: The integrated wood fiber system (Christine Burrow Consulting and Boxfish Group 2011)

RECYCLED FIBER SUPPLY & DEMAND

In 2012, 400 million tonnes of paper and paperboard were produced and consumed globally, which is double that in 1985 (FAOSTAT 2014). Increasing global populations and increasing standards of living are projected to cause this to increase by another 40% by 2028 (RISI 2013)[1].

While total consumption of paper and paperboard is projected to increase for a considerable period, consumption per unit of global GDP is expected to decline for all major grades except tissue and toweling products, representing an ongoing dematerialization of the global economy (RISI 2013). For some grades of paper and paperboard, total global production is also expected to decrease over time. For these grades, the amount of fiber available for recovery will also decline. The impact of declining production on supplies of recovered fiber from old newspapers is already being observed.

Against the backdrop of growing global demand for paper and paperboard products, finding adequate quantities of sustainably produced fiber will be a growing challenge for the global pulp and paper industry.

Recovered paper is already crucial to the global supply of fiber. In 2012, 57% of the paper and paperboard produced globally was recovered and recycled. This is projected to increase to 64% by 2028 (RISI 2013). Recycled fiber will become increasingly important in future years, especially in Asia where demand is expected to grow fastest as illustrated in Figure 4.

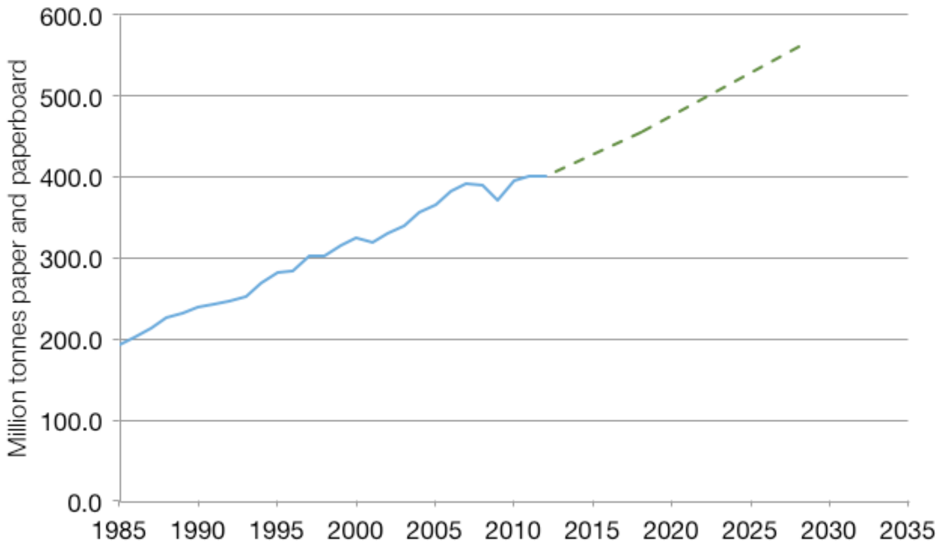


Figure 2: Global consumption of paper and paperboard (Historical data from FAOStat 2014; Projections from RISI 2013)

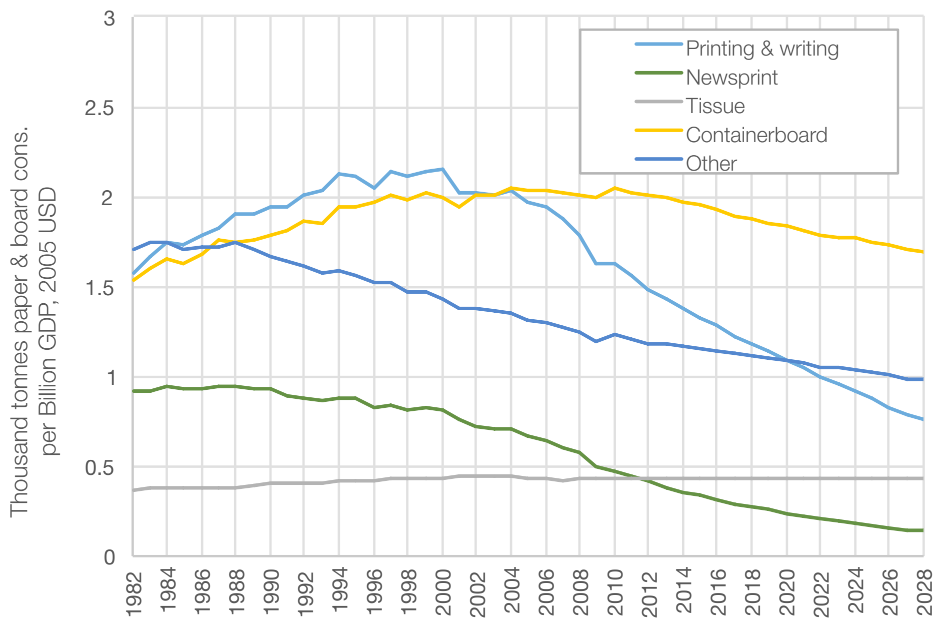


Figure 3: Global consumption of paper and paperboard per unit of GDP (RISI 2013)

[1] Although the future is always uncertain, there is value in considering how current trends might evolve in coming years. In this report, we rely on the projections of RISI, knowing that other forecasts may differ from these. Founded in 1985 and headquartered in the USA, RISI is a global company specializing in the generation and analysis of information for the forest products industry.

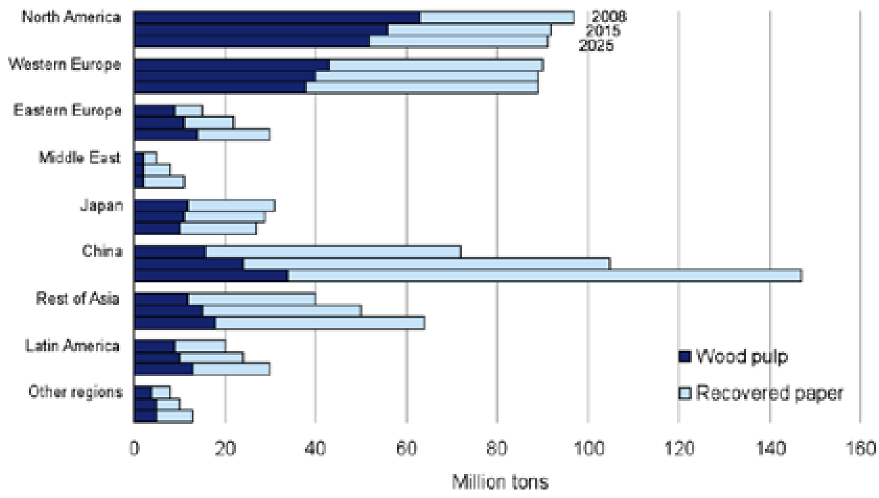
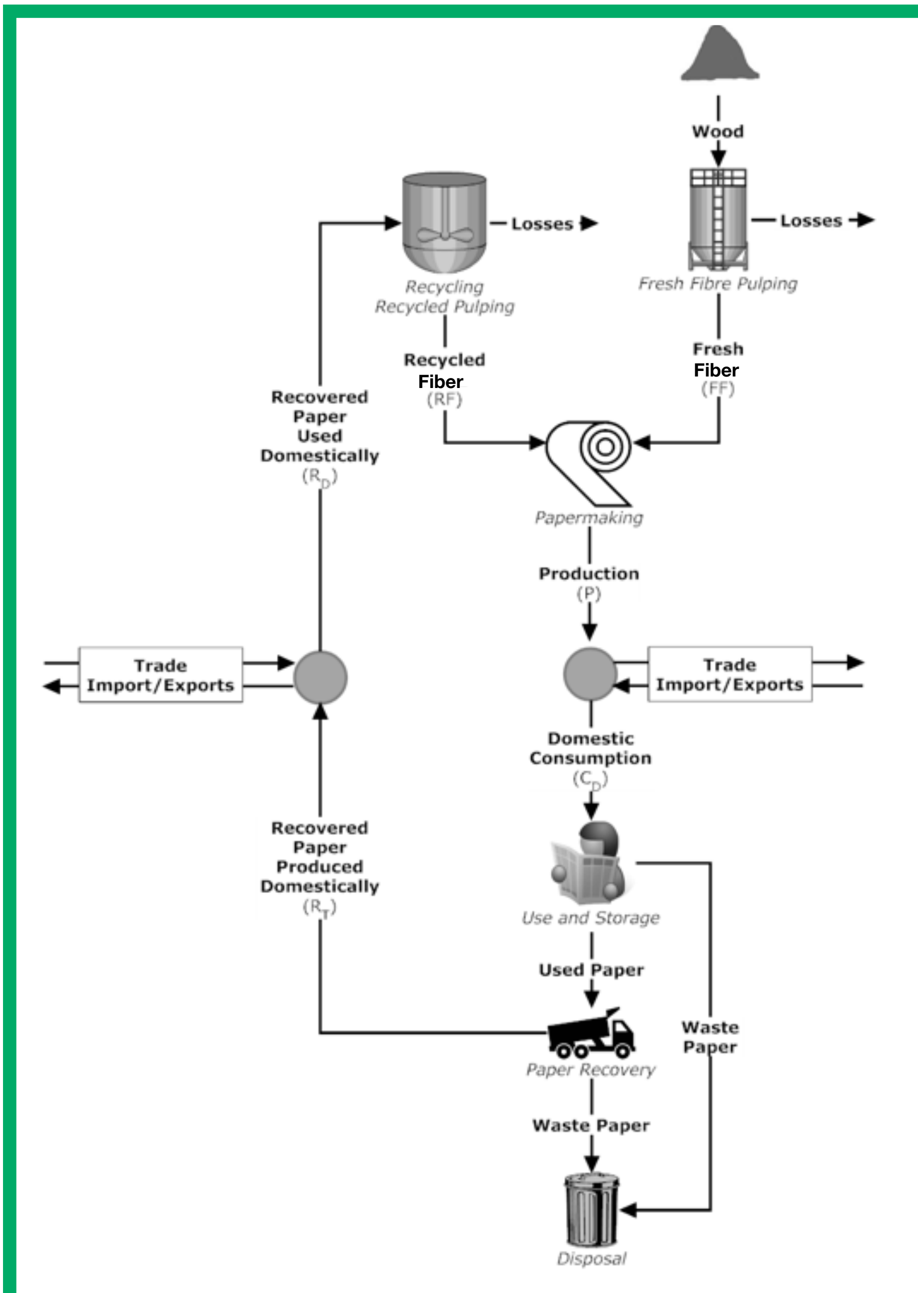


Figure 4: Recovered fiber demand by region (Pöyry 2012)



Paper recovery: The collection, separation and sorting of paper from industrial, commercial, institutional and household sources so that the fibers can be reused.

Paper recycling: The use of recovered fiber in paper and paperboard products. This is also called recovered fiber "utilization".

Domestic consumption: The amount of paper and paperboard used domestically (C_D). It is based on domestic production of paper and paperboard products (P), corrected for imports and exports of products.

Recovered paper: Quantity of paper collected for reuse. The total amount of recovered paper produced domestically (R_T) can be more or less than that used domestically (R_D) due to imports and exports of recovered paper.

Recycled fiber: Quantity of furnish to papermaking made from recovered fiber (RF). It is less than the amount of recovered fiber (R_D) due to losses occurring during processing.

Fresh fiber: Quantity of furnish to papermaking made from wood (FF). It is less than the amount of wood used due to losses occurring during processing.

Recovery rate: The total amount of waste paper collected for re-use (R_T) divided by domestic paper and paperboard consumption (C_D) expressed as a percentage.

Utilization rate: The amount of recovered paper used for domestic paper and paperboard production (R_D) divided by domestic paper and paperboard production (P), expressed as a percentage.

Recycled content: The amount of recycled fiber used domestically (RF) divided by total fiber used domestically (RF + FF), expressed as a percentage.

Figure 5: Paper recycling terminology and definitions. Based primarily on FAO definitions (FAO 2010)

Fresh and recovered fibers circulate in a global wood fiber system that moves fiber to where it is needed. Fresh fiber is generally used in those applications where it provides needed strength, brightness or surface properties at a competitive cost. Likewise, the use of recovered fiber is generally dictated by considerations of price and performance in specific applications.

While the intended use of some paper products requires a high degree of fresh fiber (e.g., archival document paper that will be stored for many years), others can readily adapt to incorporation of a large percentage of recycled fiber (e.g., boxboard). Utilization rates in Europe for newsprint and case material (a.k.a. containerboard) already exceed 90% (CEPI 2013). For yet others (e.g. packaging), varying amounts of recycled fiber may be incorporated depending on fiber costs and product quality constraints. For many paper and paperboard products, the incorporation of a fraction of recovered fiber is standard practice. Both types of fiber can be used for papermaking – and neither is inherently better or worse than the other.

Fresh and recovered fibers require different types of processing equipment to prepare the fiber for use in a paper product, and often have different characteristics and costs. The cost differences between fresh and recovered fiber are variable over time. For instance, as shown in Figure 6, for most of the 1990s fresh softwood fiber in wood pulp was more expensive in the United States than comparable recovered fiber in old corrugated containers (OCC). Beginning early this century, however, the price difference started to narrow considerably. Figure 6 also highlights the dramatic changes that occur in OCC prices from year to year, a feature common to all grades of recovered paper.

Despite the substantial role that recovered fiber plays in the overall global fiber cycle, the importance of inputs of fresh fiber to the fiber cycle cannot be overstated. Inputs of fresh fiber are important for several reasons. First, there are limits to the amount of used paper that can be recovered (called the maximum practical recovery rate). The recovery rate is approaching 70% in the United States (ICFPA 2013), slightly exceeds 70% in Europe (CEPI 2013) and is approaching 80% in Japan (RISI 2013). Second, there are unavoidable losses of fiber during recovered paper processing and reuse. Third, fiber degrades with multiple uses requiring the addition of fresh fiber to meet quality requirements for many paper and paperboard products. A report by Metafore (2006) examining the use of recovered fiber in North America found that even at the highest possible recovery rate, the fiber cycle will continue to require significant inputs of fresh fiber as fiber shortages would develop in a matter of days if fresh fiber input were eliminated.

Takeaways
Maximising societal values from trees

- Recycling provides a substantial contribution to global fiber supply and contributes to sustainability.
- Recycling is a critical part of the eco-efficient, cascading system of wood fiber utilization, ensuring that the value of the wood resource is maximized.
- Recycling is part of the renewable cycle of wood and fiber-based products.

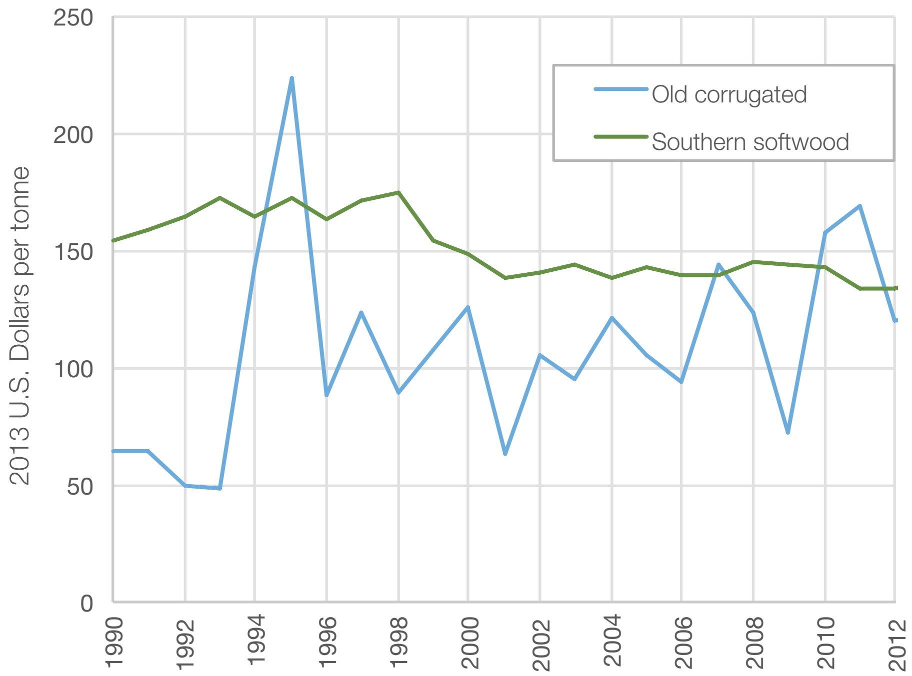


Figure 6: Equivalent prices of old corrugated containers and softwood fiber (RISI 2013)

ECO-EFFICIENCY BENEFITS OF PAPER RECOVERY, RECYCLING, CASCADING

Recycling of used paper is not only an important contribution to the global fiber supply for pulp and paper manufacturing, but is also a significant component of the overall value to society that can ultimately be derived from the forest. The increased reliance on renewable materials such as biomass has now expanded into a variety of roles well beyond that of traditional paper products – and will continue to grow as society seeks approaches to develop long-term solutions to complex challenges related to climate change and global materials supply. To the extent that the overall value to society from each harvested tree can be optimized, there will continue to be an expansion and evolution of the forest-derived products that are derived from this renewable cycle.

The concept of deriving maximum value from the use of forest biomass has become recognized as the principle of "cascading". In a cascading system, rather than simply using a harvested tree to create a single product, this value chain is internally expanded to seek opportunities for manufacturing a series of higher value-added products that are reused and/or recycled into a series of subsequent forest products (e.g., wood pellet manufacture from lumber production waste, or use of recovered fiber to produce recycled paper), with bioenergy generation only occurring prior to disposal.

Recycling of paper is a critical part of the cascading wood fiber system.
The fiber flows within the EU's cascading wood fiber system are shown in Figure 7 (Mantau 2012). The demand for biomass for energy production has increased due to government policies seeking renewable energy sources to displace fossil fuel, in the interest of reducing emissions of greenhouse gases, and the "cascading principle" has now been embedded into the EU policy foundation for bioenergy, as a necessary part to ensure long-term sustainability of forest resources and maximized value to society from their use (EC 2013, EC 2014).

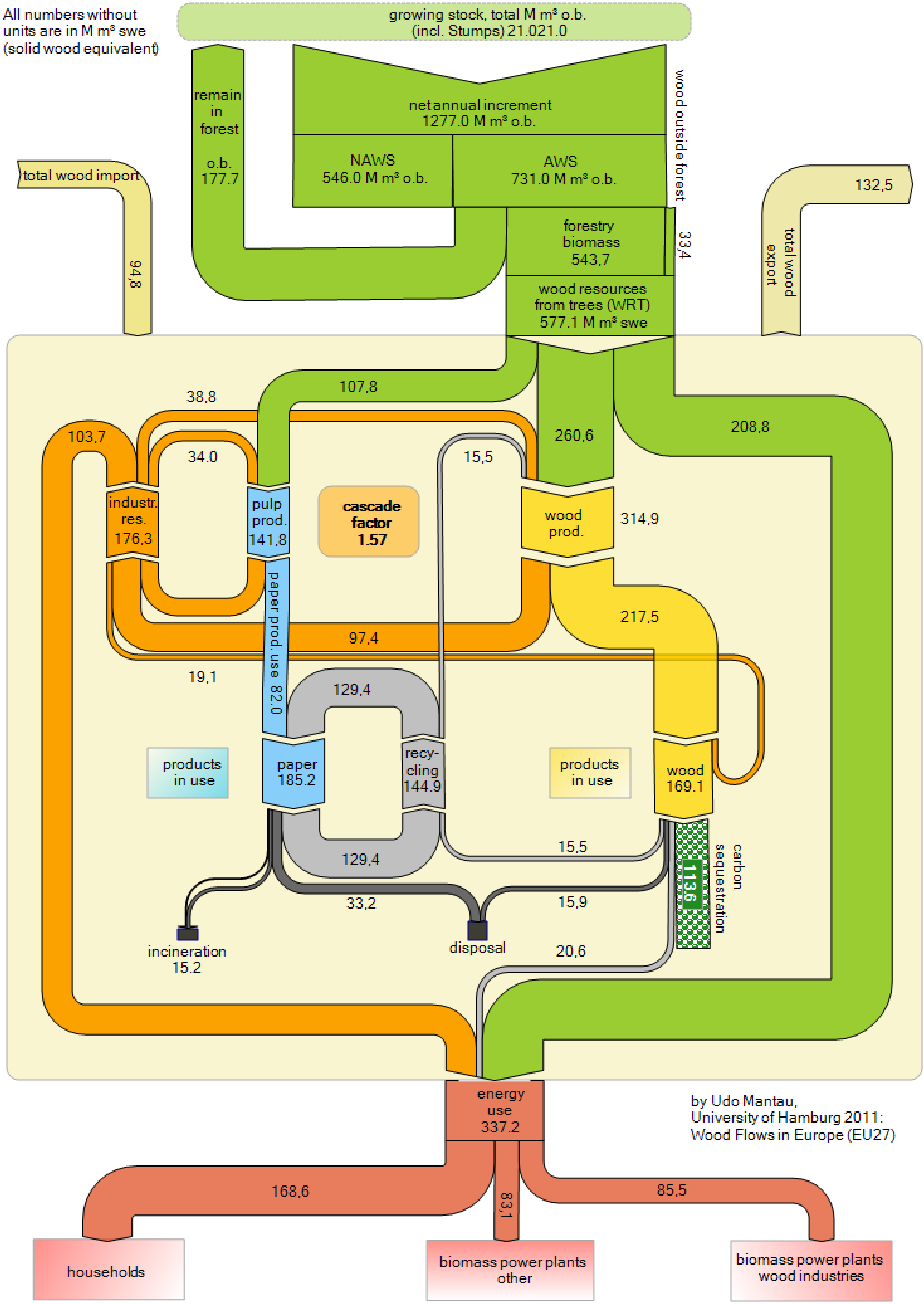


Figure 7: Cascading fiber flows in the EU27 (Mantau 2012)

ENVIROMENTAL IMPACTS OF PAPER RECYCLING

While the demand for recovered fiber is driven primarily by economic factors, paper recovery and reuse has also been motivated by a societal desire to reduce the life cycle environmental impacts of paper and paperboard production. Some of the environmental and resource implications of increased paper recovery and utilization seem relatively clear on the surface. Increasing paper recovery, for instance, reduces the amounts of used paper requiring disposal. Increasing recovered fiber utilization reduces demand for fresh fiber.

When examined carefully, however, it becomes clear that the effects of paper recovery and utilization on environmental quality and resource depletion are complex[2]. Many studies have been undertaken over the last several decades attempting to understand these complexities. The result has been a growing recognition that increasing recovery and utilization involves many environmental trade-offs and well as a variety of co-benefits (see, for instance, EEA 2005, Finnveden and Ekvall 1998, NCASI 2011, Villanueva and Wenzel 2007, Wenzel and Villanueva 2006, NCASI 2013).

Takeaways
Understanding impacts

- It is key to recognize trade-offs and co-benefits between using fresh and recovered fibers.
- Life-cycle assessment (LCA) can help reveal trade-offs and co-benefits.
- LCA requires simplifying assumptions which limit the ability to make definite conclusions about the comparative environmental impacts of fresh and recycled fibers.
- Displacing fresh fiber with recycled fiber can sometimes have unexpected life-cycle consequences.

5.1 LIFE CYCLE ASSESSMENT AND OTHER TOOLS FOR UNDERSTANDING RECYCLING

Life cycle assessment (LCA) is a tool used to assess the potential environmental impacts of a product's life cycle, i.e., from raw material extraction to the product's end-of-life, whether that end-of-life is reuse, recycling or final disposal. Standard methods have been developed for conducting LCA studies, most notably the ISO 14040 series of standards issued by the International Organization for Standardization (ISO) (ISO 2006a, 2006b, 2012a, 2012b).

LCA can help quantify the environmental benefits and impacts attributable to a specific product and provide insights into how these attributes may change in response to a change in the product system. For instance, LCA can help determine if waste reduction measures at one point in the life cycle are likely to result in increased waste generation or other impacts elsewhere in the life cycle. While LCA is a valuable tool, it is data intensive and often requires simplifying assumptions, discussed later in this document. In addition, good quality data are often lacking for at least some elements of an LCA study, producing uncertainty in the results.

In using LCA to study recycling, it is important to carefully define the objective of the study. In particular, it is important to decide whether the objective is to characterize a product system that involves recycling or to understand the impacts that occur if you change the system. Studying the attributes of a product system in isolation requires a different analytical framework than that used to study the consequences of, for instance, increasing recovery or utilization rates. The framework used to understand the attributes of a product system in isolation is often called attributional LCA while the framework used to study the consequences of changes to the system is often called consequential LCA.

Using LCA to characterize the attributes of a recycled product system (i.e., attributional LCA) requires the analyst to estimate the actual transfers of substances and energy across boundaries that encompass the system being studied. Using LCA to understand the implications of changing recovery or utilization rates (consequential LCA), however, is far more complex as it also requires understanding how these transfers will change and how this will in turn affect the resource demands and emissions from other systems.

Ultimately, understanding the overall impacts of increasing paper recovery and utilization requires understanding how flows of fiber throughout the wood fiber system are affected by changes in supply and demand for fiber and products. Due to the difficulty of modeling the market dynamics of these systems, simplifying assumptions are usually made, often without understanding the potential impacts of these assumptions on the results of the analysis. This limits the ability to make definitive conclusions about the environmental benefits of increasing paper recovery and utilization, and greatly complicates the ability to compare the environmental attributes of fresh and recycled fibers.

While LCA is useful, it is only one of many tools that can be used to understand paper recycling. Each tool has its own strengths and weaknesses and each provides a different perspective on impacts. Other life cycle-based tools include Social Life Cycle Assessment (S-LCA) and Life Cycle Costing (LCC) (UNEP-SETAC-Life cycle initiative,

[2] See Figure 5 for definitions of recovery, utilization and other terms used in this document.

2009). LCA-based methods can be informed by economic models (e.g., partial or full equilibrium econometric models). Models of land use change and forest management can also provide important input to LCA studies of the wood fiber system. Other tools that focus on different environmental issues (e.g. risk assessment) can also complement LCA. Any single tool will give an incomplete picture of the impacts of recycling. To the extent these tools can be used together in an integrated assessment, the understanding of the impacts of fiber recovery and recycling will be improved.

5.2 CURRENT UNDERSTANDING OF IMPORTANT TRADE-OFFS AND CO-BENEFITS

Takeaways
Trade-offs

- Recycled fiber processing releases lower amounts of air pollutants, but generates significant amounts of solid waste.
- Fresh fiber production and processing usually requires more energy than recycled fiber processing, but it relies on renewable energy to a greater extent than recycled fiber processing.
- Effects of increased use of recovered fiber on forest carbon stocks are often unclear.
- A reduction in demand for wood can increase the chance that forests will be permanently converted to other land uses.
- Single stream recycling may increase overall recovery rates, but can cause adverse effects on fiber quality.
- Fiber characteristics dictate which types of fresh and recycled fiber can be used in a given paper or paperboard product.

Recovered fiber begins its life as fresh fiber in harvested wood. Understanding the environmental impacts of recycling therefore requires understanding the differences in pulp production processes for fresh and recycled fiber as well as results of life cycle assessment (LCA) studies aimed at comparing fresh and recycled fiber.

5.2.1 Environmental releases from fresh and recycled fiber production processes

Mills that produce fresh fiber pulp use different processes than those producing recycled fiber pulp so the releases to the environment differ. Fresh fiber (wood) can be pulped by chemical or mechanical means. Chemical wood pulping involves cooking wood chips or sawdust in an aqueous solution of pulping chemicals, resulting in the extraction of cellulose from the wood by dissolving the lignin that binds the cellulose fibers together.

While significantly reduced through use of pollution control equipment, the chemical pulping process can be a source of releases to the environment. Depending on the specific pulping process, these releases can include odorous sulphur compounds (sometimes called total reduced sulphur or TRS), volatile organic compounds (VOCs), hazardous air pollutants (HAPs) and sulphur dioxide (SO_2), as well as waterborne biochemical oxygen demand (BOD) and chemical oxygen demand (COD). The chemicals used in pulping are recovered in a process that can emit particulate matter, TRS, SO_2, nitrogen oxide (NOx), carbon monoxide and VOCs. Some solid wastes are generated during chemical recovery but they are generally not significant compared to other sources at pulp and paper mills.

Mechanical pulping relies mainly on mechanical energy to convert wood to pulp. Very little of the lignin is removed in the mechanical pulping process; thus, pulp yields are higher than for chemical pulping processes. The high temperatures found in mechanical pulping processes evaporate some of the more volatile material in wood. These volatile organic compounds (VOCs) are treated with pollution control equipment, but even with efficient equipment, some of the gases are released as VOCs (Sundholm 1999).

Recycled fiber production starts with pulping recovered fiber, where the incoming paper is wetted and fragmented into individual fibers. This is followed by mechanical removal of contaminants with or without deinking and brightening. In general, recycled fiber processing has the potential to release lower amounts of air pollutants than fresh fiber processing. However, it generates significant amounts of solid waste. Where deinking is required (e.g., for processing recovered mixed office papers in the production of copy paper), releases to water and generation of solid waste are greater than where recovered fiber can be used without deinking (e.g., for using recovered OCC in the production of paperboard).

Whether recycled or fresh fiber is used to produce pulp, total emissions to air are strongly related to fuel combustion for energy. Recycled fiber mills usually use less total energy than fresh fiber mills because it is not necessary to apply energy to break the tight bonds between fibers that exist in wood. As a consequence, energy-related emissions are often lower for mills using recovered fiber than for mills producing fresh fiber.

That said, chemical pulping mills generate much of their energy using biomass, a renewable fuel.

5.2.2 Life cycle studies comparing recycling to disposal

Life cycle thinking is required to understand the system-wide implications of increasing paper recovery, beyond those expressed in Table 1.

In general, LCA studies show that the effects of increasing recovery of paper are relatively clear when the alternative is landfilling used paper. This is a major reason why the European Union's 1999 Landfill Directive obliges Member States to reduce the amount of biodegradable municipal waste going to landfills to 35% of 1995 levels by 2016, or by 2020 for some countries (EC 2014a). It is also why the European Commission has proposed banning the landfilling of recyclable materials, including paper and paperboard (EC 2014b).

Table 1 summarizes the potential mill-level environmental effects of increasing the use of recycled fiber (i.e., not using a life cycle approach that goes beyond the mill itself).

Table 1: Effect of increased recycled fiber use on the environmental releases from pulp and paper mills (Sources identified in Annex 1)

<table>
<tr><th>Effect</th><th>Releases are significantly increased</th><th>Releases are somewhat increased</th><th>No effect on Releases</th><th>Releases are somewhat reduced</th><th>Releases are significantly reduced</th></tr>
<tr><td>Water</td><td></td><td></td><td colspan="3">Mills that produce and use recycled fiber pulp typically use less water. However, attempts to use more recycled fiber usually have little effect on water use compared to other factors.</td></tr>
<tr><td>Total energy use</td><td></td><td></td><td colspan="3">In general, mills that produce and use recycled fiber pulp use less total energy. This is because far more energy is required to convert wood into separate fibers than is required to convert recovered paper into useable fibers.</td></tr>
<tr><td>GHGs and fossil fuels</td><td colspan="4">In general but not always, mills that produce and use recycled fiber pulp use more fossil fuels and generate more GHGs because they lack access to, and combustion devices for, biomass fuels. However, this is very dependent on the paper grade and mill configuration. Some recycled paper mills, for instance, use purchased steam to make paper, eliminating the need to use fuel to produce steam at the mill.</td><td></td></tr>
<tr><td>Chlorinated compounds</td><td></td><td></td><td colspan="2">For grades that require bleaching, there are often lower levels of AOX (a measure of the amounts of chlorinated compounds) from recycled fiber processing.</td><td></td></tr>
<tr><td>Odor</td><td></td><td></td><td colspan="2">Recycled fiber processing produces less odor than some fresh fiber processes.</td><td></td></tr>
<tr><td>Emission to air</td><td></td><td></td><td colspan="2">There are generally fewer emissions to air from mills that produce and use recycled fiber pulp.</td><td></td></tr>
<tr><td>Discharge to water</td><td></td><td></td><td colspan="3">Depending on the paper grade, the discharges to water are the same or better for mills that produce and use recycled fiber pulp.</td></tr>
<tr><td>Solid Waste</td><td></td><td>Mills that produce and use recycled fiber pulp generally generate more solid wastes.</td><td></td><td></td><td></td></tr>
</table>

If the alternative to recovery is burning with energy recovery, however, the results of the comparison vary (see, for instance, the following literature reviews: (see Table 2) EEA 2005, Finnveden and Ekvall 1998, NCASI 2011, Villanueva and Wenzel 2007, Wenzel and Villanueva 2006). The lower impact option can vary, for instance, among different impact indicators (e.g. global warming vs. eutrophication). In addition, the results can be significantly affected by the type of energy assumed to be displaced by the energy generated from burning. Within the context of an efficient cascading system, however, where recyclable fibers are diverted from disposal, burning for energy would not act as an alternative to recycling, but as an eco-efficient means of gaining value from fibers that have no higher-value use.

Even in studies comparing paper disposal to paper recycling, the assumptions made about the impacts of using recovered fiber are important to study results. In many studies, recycling is assumed to displace fresh fiber and it is often assumed that the reduced demand for fresh fiber allows forest carbon stocks to increase as harvesting is reduced. In reality, the effects of increased use of recovered fiber on forest carbon stocks are unclear. In some locations, especially where wood-producing land is privately owned, a reduction in demand for wood increases the likelihood that the land will be converted from forest to other more profitable uses (Hardie et al. 2000, Lubowski et al. 2008). Another assumption that can have a significant effect on the results of LCA studies is the substitution ratio between fresh and recycled fiber. Recycled fiber may not have the same characteristics as fresh fiber and hence a 1:1 ratio cannot necessarily be assumed.

5.2.3 Life cycle effects of increased use of recycled fiber in paper

While it is possible to draw several general conclusions about the effects of recycling as an alternative to other end-of-life options, it is more difficult to compare the environmental attributes of fresh and recycled fiber and to understand the effects of increased use of recycled fiber in specific products. Comparing the environmental attributes of fresh and recycled fibers requires artificially separating the integrated wood fiber system into two parts – a fresh fiber system and a recovered fiber system. Estimating the environmental attributes of each system requires that the environmental releases from the wood fiber material life cycle be divided between the fresh and recycled fiber systems. This is usually done using decision rules called allocation methods.

Box 1: Environmental impacts

"…the majority of LCAs indicate that recycling of paper has lower environmental impacts than the alternative options of landfill and incineration. The result is very clear in the comparison of recycling with landfilling, and less pronounced, but still clear, in the comparison of recycling with incineration."

(EEA 2006)

There is no single correct allocation approach for studies of systems involving paper recycling, yet allocation decisions can significantly affect the results of such studies (NCASI 2012, Cederstrand et al. 2014). Ultimately, while decisions on allocation methods are seldom right or wrong, they frequently reflect value judgments made by the analyst. Given their potential effect on the outcomes of LCA studies, these decisions and value judgments should be transparently communicated so the reader is aware of the basis for the analysis in question.

Given the importance of marketplace dynamics to the availability and use of recovered fiber within the overall global fiber system, there is a need for studies that incorporate market-related responses. There are very few such studies, however. Byström and Lînnstedt (1997) used LCA combined with optimization and simulation tools to demonstrate that forcing the use of recycled fiber in products that normally rely on chemical pulp may not be beneficial from a GHG standpoint. This study illustrates that displacing fresh fiber with recycled fiber can have unexpected life cycle impacts.

Due to the complexity of market-related effects, these effects are normally either ignored or modeled based on assumptions. In addition, to simplify the analysis, most studies of recycled and fresh fiber apply fairly straightforward allocation methods that may ignore certain complex interactions. Consequently, although the environmental benefits of recycling are generally recognized, it is very difficult to determine whether the use of recycled fiber within a specific product will lead to measurable environmental benefits.

Table 2: Life cycle environmental Impacts of paper recycling compared to alternative management options
(see for instance the following literature reviews: EEA 2005, Finnveden and Ekvall 1998, NCASI 2011, Villanueva and Wenzel 2007, Wenzel and Villanueva 2006)

Environmental indicator	Landfilling	Incineration with energy recovery
GHGs	↓	Results vary
Water use	↓	Inadequate information
Total energy use	↓	Results vary
Wood use	↓	↓
Acidification/SO^2	↓	Results vary
Water quality (e.g., eutrophication)	↓	Results vary
Photochemical oxidants/VOCs	↓	↑
Toxicity	Inadequate information	Inadequate information
Waste	↓	Approximately equal

↓: Lower environmental impact from recycling, ↑: Higher environmental impact from recycling

Box 2: Examples of allocation decisions in LCA studies of paper production and recycling

Lumber Mill A produces dimensional lumber and wood chips. The wood chips are subsequently converted into fresh fiber pulp by Paper Mill B and the mill uses the pulp to make copy paper. The copy paper is subsequently recovered and used by Paper Mill C to make facial tissue which is disposed after use. Emissions are generated at each mill. Among the important allocation decisions raised by this flow of wood fiber are:

- Should the emissions from Lumber Mill A be divided between the lumber it produces and the wood chips it produces? If so, how?

- Should the copy paper and facial tissue share (a) the emissions from Lumber Mill A associated with producing the wood chips and (b) the emissions from Paper Mill A that were associated with converting the wood chips into fibers useable in copy paper and facial tissue? If so, how?

- Should the copy paper and facial tissue share the emissions from the recycling processes (e.g., paper collection and sorting, pulping of recovered fibers)? If so, how?

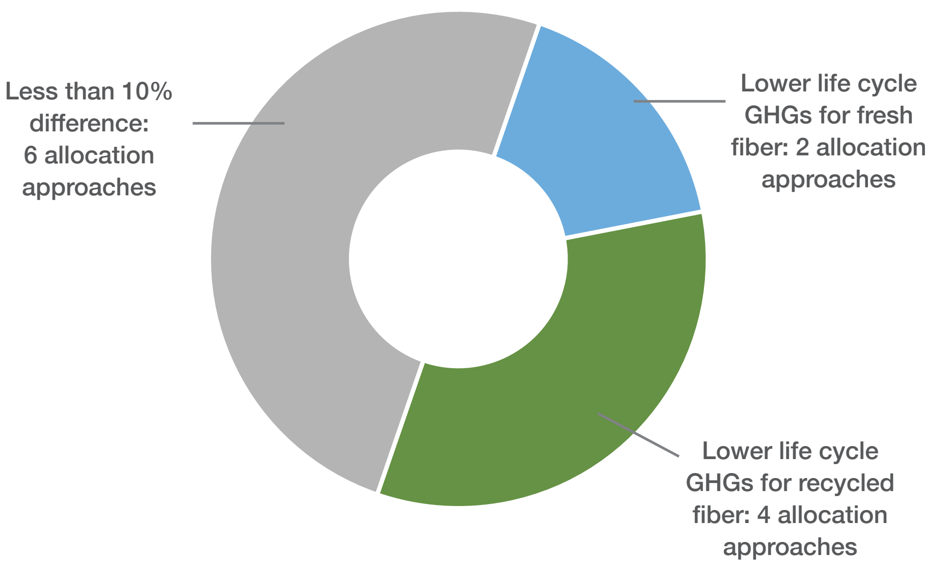


Figure 8: A study of 12 allocation methods found that the selection of allocation method can determine the results of environmental comparisons of recycled and fresh fiber (NCASI 2012).

RECOVERED FIBER QUALITY

To make wood fiber useable in paper, the fiber must be “activated” in the pulping process (Stürmer and Göttsching 1979), forming strong bonds between fibers that give paper its strength. Fresh fibers in pulp are at the highest level of activation for forming strong paper that they ever will be in their lifecycle. Fibers can be “deactivated” by a number activities including drying and processing for recycling. These activities cause physical and chemical changes to fiber, resulting in recycled fibers being generally weaker and more brittle than fresh fiber, and less suitable for some types of paper and paperboard products.

Recycled fiber is also different from fresh fiber in terms of the materials that must be removed from the feedstocks (recovered paper or wood) in order to make the fiber useable. Preparation of recycled fiber involves separating the fiber in previously manufactured paper from residual contaminants such as inks, glues, and plastics. There are dozens of different types, or “grades” of recovered paper (e.g., see BSI 2014), containing different fiber types, higher and lower levels of residual contaminants and reflecting the degree to which the paper has been separated from other materials such as other household recyclables (e.g., plastics). Indeed, the Institute of Scrap Recycling Industries in the U.S. has definitions for 52 different grades of recovered fiber (ISRI 2014).

Some grades of recovered paper, such as old corrugated containers and waste from printers, are largely collected by private firms directly from commercial establishments. These sources provide a large fraction of the available quantities of some types of recovered paper. Paper discarded by households, however, is usually collected by municipalities. For instance, in Europe, 40% of recovered paper comes from households (PITA 2010). The methods used by municipalities to collect household-generated material affect both the quantities and quality of the recovered paper.

In some places, the United States for instance, municipalities are increasingly asking households to combine all recyclable materials into a single collection container, a method called single stream, single sort or commingled recycling. Commingled recycling has contributed to higher recovery rates, making more recovered fiber available, but it has also significantly and adversely affected fiber quality.

Box 3: To allow fiber quality to be matched with product requirements recovered paper has been divided into a large number of different grades. There are, for instance, four different types of recovered newsprint described in the ISRI specifications, not including newsprint contained in non-newsprint grades.

- Old Newspaper: Consists of sorted newspapers and other acceptable papers as typically generated by voluntary collection and curbside collection programs.

- Regular News, De-ink Quality: Consists of sorted, fresh newspapers, not sunburned, and other acceptable papers. This grade may contain magazines.

- Special News, De-ink Quality: Consists of sorted, fresh newspapers, not sunburned, and other acceptable papers. This grade is to be relatively free from magazines and contain no more than the normal percentage of rotogravure and colored sections.

- Over-Issue News: Consists of unused, overrun newspapers printed on newsprint, containing not more than the normal percentage of rotogravure and colored sections.

- Each of these has different requirements for “prohibited materials”, “outthrows”, and “other acceptable papers”.

(ISRI 2014)

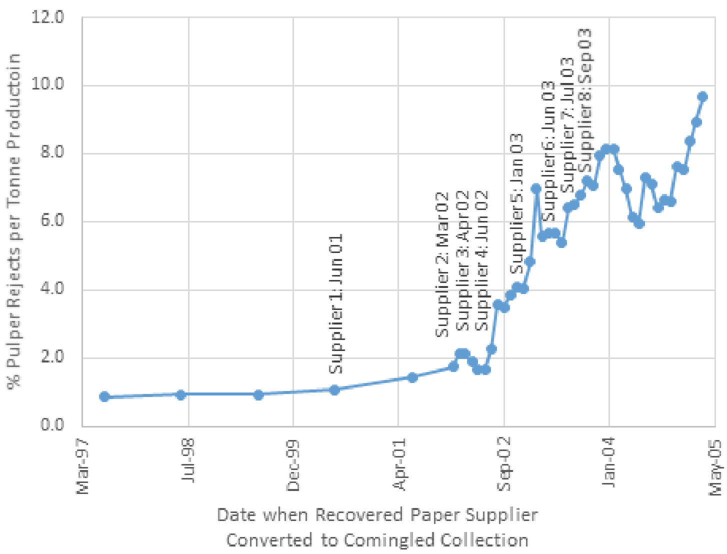


Figure 9: Mill losses increase as suppliers convert to comingled collection (Sacia and Simmons 2006)

This adverse effect on fiber quality has increased the fiber cleaning requirements at mills using recovered fiber and, to a certain extent, shifted the responsibility for disposing of non-usable contaminants from the municipalities to the mills. A newsprint mill in the U.S., for instance, has reported that as its fiber suppliers moved to collection of comingled materials, the mill's pulper rejects, which are landfilled and consist primarily of plastics, tin, glass and aluminum, increased by 800% (see Figure 9) (Sacia and Simmons 2006).

The trend towards commingled collection has also complicated efforts to increase the use of recovered fiber in grades with high fiber quality requirements. A study of the impact of commingled collection in the UK, for instance, revealed that

"…the quality of recovered paper from commingled systems is very far from the quality obtained with selective systems… This fact limits significantly the use of this recovered paper for graphic paper production where the major potential for an extended use of recovered paper in papermaking lies"

(Miranda et al. 2013).

Generally speaking, recovered fiber can only be used to produce new paper of an equal or lower grade. For example, while it is possible to use fiber from recovered copy paper to make new copy paper (a product with high quality requirements to ensure proper operation of copy machines) it is more straightforward to use recovered office paper to produce household tissue. In many cases, recovered fiber is reused into the type of product from which it was recovered. For instance, recovered fibers from case material (also known as containerboard) are largely reused to make new case material. Similarly, newsprint is largely recovered and reused to make new newsprint.

Box 4: Single stream recycling

A study of the impact of single stream recycling in the United States found that *"… there was a net increase of all materials recovered in curbside recycling of 1 to 3 percentage points. However, because of the higher level of prohibitives in recovered fiber from single stream programs…approximately 1% more recovered fiber would be required to generate the same quantity of recycled paper and board [product]."*

(Null and Skumatz 2004)

Box 5: Recovery rates

While higher recovery rates help meet the growing demand for wood fiber, it is clear that higher recovery rates also present challenges to paper and paperboard mills and suggest *"special attention […] to development and improvement of collection methods, sorting systems and sorting techniques."*

(PITA 2010)

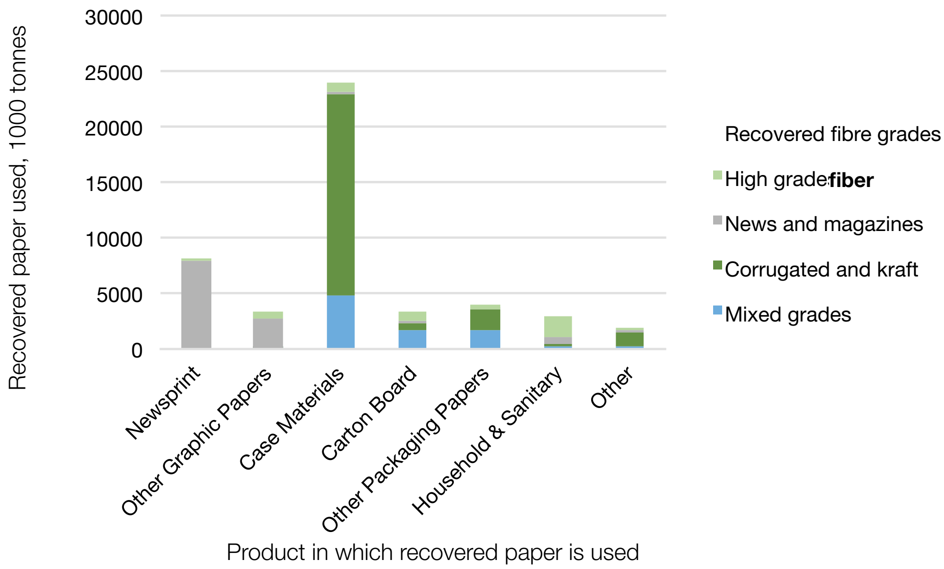


Figure 10: Sources of recovered paper used to make different grades of paper and paperboard in the EU (from data in CEPI 2013)

Fiber flows involve a complex web of interactions. Figure 11 shows a fiber flow map representative of the US paper and paperboard industry for 2011.

In countries with high recovery rates, the grades of paper where recovered fiber is used most easily already contain high levels of recovered fiber. An increasingly difficult challenge is the scarce availability of recovered fiber of adequate quality for grades having lower recovered fiber content: e.g., graphic papers.

As a natural material, wood fiber is negatively affected by repeated recycling, and is ultimately shortened and weakened to the point that it is no longer suitable for use in papermaking and it leaves the system as part of the waste stream or may be used elsewhere (e.g. as fuel). On average, including its initial use, wood fiber can be used only five to seven times before its quality becomes too degraded for further use (Göttsching and Pakarinen, eds. 2000). The life of a fiber can be extended by "down-cycling" or using it in successively less demanding products.

In Europe, producers of packaging grades have found that "the average fiber length is getting shorter and the fiber can show signs of multiple use. To balance this, process paper mills are forced to use more process chemicals and introduce either virgin [fresh] pulp or carefully selected sources of Recovered Paper to rejuvenate the fiber properties" (PITA 2010).

Steady state material balance models have been developed to calculate the effects of recycling on the age of fibers (Ackermann et al. 2000; Cullinan 1992). Figure 12 shows the age distribution of fiber in a hypothetical product as a function of utilization rate calculated with the one-parameter model presented in Göttsching and Pakarinen (2000). A number of important points are clear.

- At utilization rates of 50% or less, the average number of fiber "ages", defined by the number of fiber uses, within a product is low, but increases rapidly with increased utilization rate.
- At a utilization rate of 75%, fibers used more than four times make up over 30% of the total.
- Especially at high utilization rates, the age distribution of a country's domestic fiber supply is likely to be influenced by the age distribution of fibers contained in imported products that are eventually recovered and recycled.

Age distribution models can also be used to determine the amount of fresh fiber requirements for markets and to determine the longevity of fiber supplies without inputs of fresh fiber (Metafore 2006). Studies have shown that the US, Canadian, and European markets would be devoid of raw material within six months without a constant fresh fiber input (Metafore 2006; Ervasti 2011).

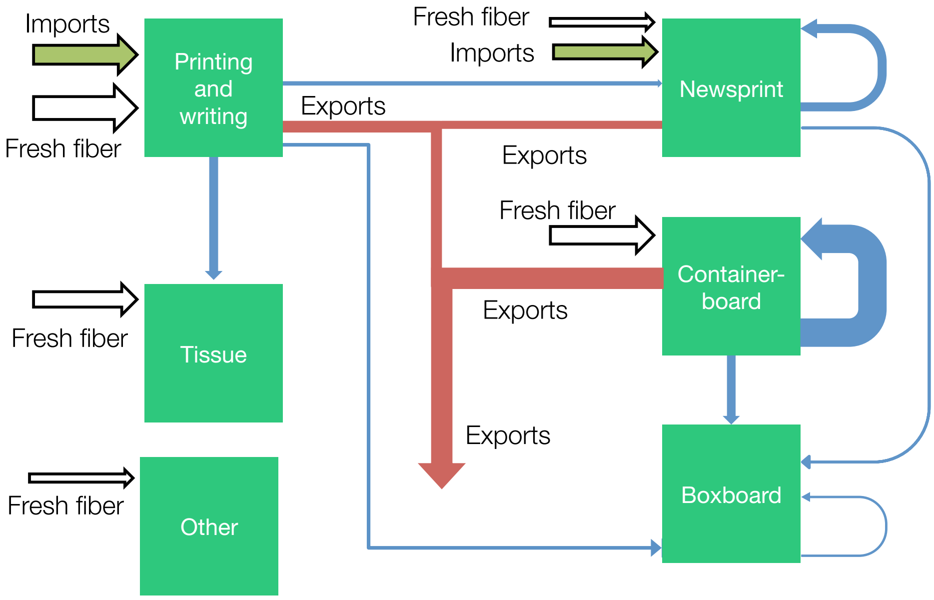


Figure 11: Flow map for the US paper and paperboard industry addressing the major flows of recovered fiber: width of line corresponds to fiber amount, blue arrows are internal fiber flows; green arrows are imported fiber flows; white arrows are fresh fiber flows; and orange arrows are exported fiber flows. Based upon data from AF&PA (2012)

Box 6: Increasing utilization of recovered paper

[In Europe,] *"the paper grades that can absorb large amounts of relatively low quality recovered paper, i.e., newsprint and case materials, are already quantitatively satisfied with recovered fibers. Any significant increase in the overall utilization of recovered paper therefore will only be possible using higher quality printing & writing papers. They, however, require either recovered paper of a higher quality in terms of cleanliness (specks, ink residues and stickies) or more powerful and selective though economic treatment technologies. Neither of them is available at the moment."*

(PITA 2010)

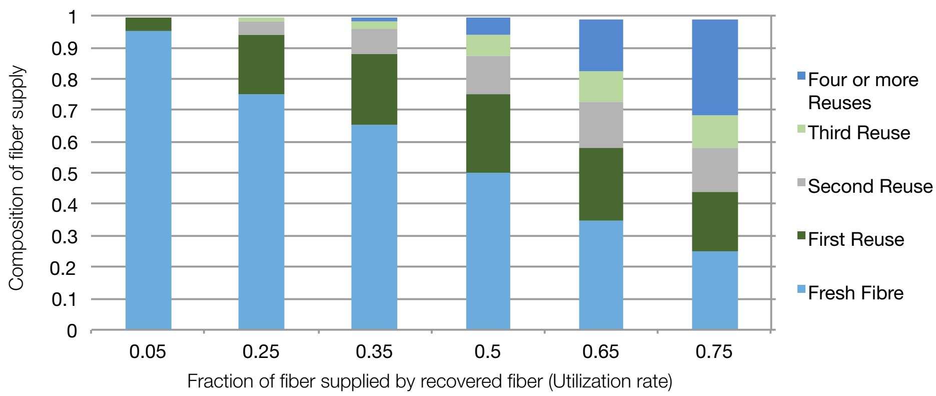


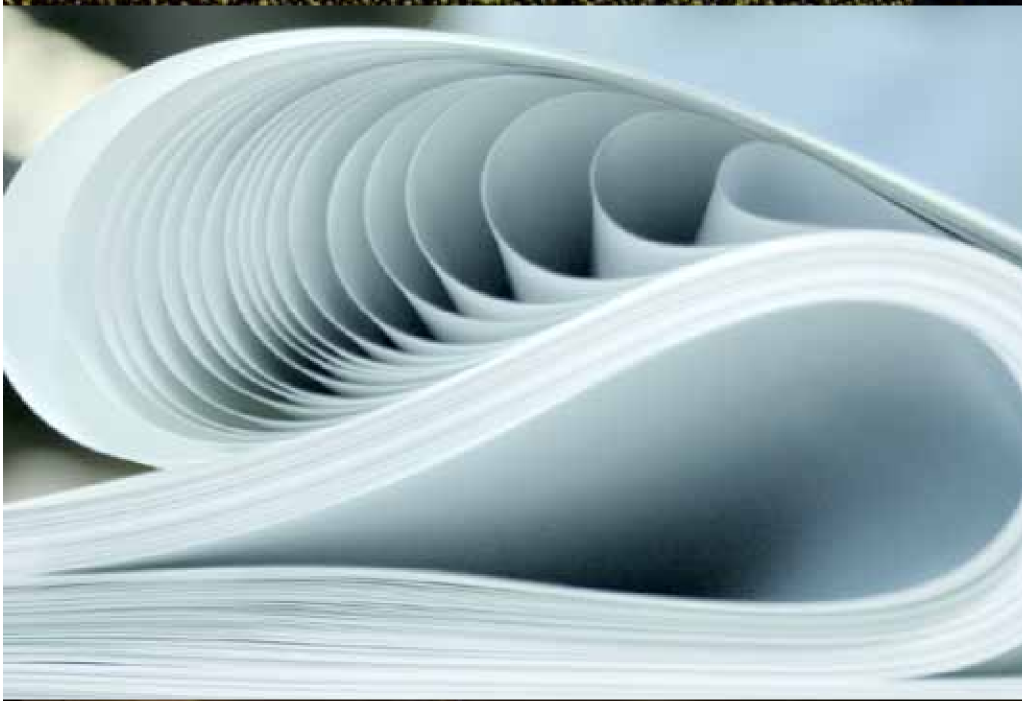
Figure 12: The effect of recycling on fiber age (based on the model in Göttsching and Pakarinen 2000)

DESIGN FOR RECYCLE

In some cases it has proven possible to design paper and paperboard products so as to eliminate materials that cause problems when the product is recycled. An example is the use of adhesives that can cause problems with 'stickies' in the paper mill. Stickies are contaminants that can deposit on mill equipment causing operational problems and can affect the appearance and performance of paper and paperboard products. These sometimes originate as adhesives used in products that are later recovered for recycling. A recognition that pressure sensitive adhesives were causing problems in recycling lead to the development of alternatives called recycling compatible adhesives designed to reduce the problem with stickies.

Boxes designed to carry wet materials are sometimes coated with wax to make them water resistant. Unfortunately, wax is very difficult to remove in recycling processes and so wax-coated materials are often excluded from recycling programs. Recognizing this, the packaging industry has developed a number of recyclable alternative coatings that are now becoming commercially available.

There are many more examples of steps that have been taken to make paper and paperboard products more recyclable. As recovery and utilization rates continue to increase, further work will be needed to eliminate potential contaminants by excluding them from the initial production process and in turn, from the recycled fiber process.



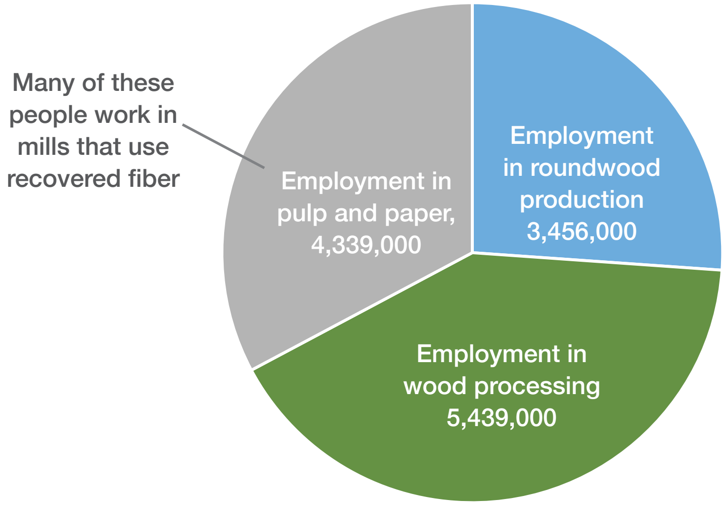


Figure 13: The formal global forest sector employs over 13 million people (FAO 2014)

SOCIETAL ASPECTS OF FIBER RECOVERY & RECYCLING

The formal global forest sector employs over 13 million people, divided among jobs in forestry, wood products production and paper and paperboard production, as shown in Figure 13. A significant fraction of the 4.3 million people working in the paper and paperboard sector are working in mills that use recovered fiber. The precise number is not known, in part because recovered fiber is used in so many mills. Even mills producing fresh fiber from wood often combine fresh fiber with recovered fiber to make their products.

Takeaways
Societal benefits

- Within the context of the global forest sector, recycling creates jobs for millions of people.
- In developed countries these jobs are largely in the formal economy while in developing countries, many recycling-related jobs are informal.
- Society benefits from the environmental ethic that recycling activities instill.

Although difficult to quantify, it is clear that recycling provides jobs and other economic benefits within the context of the global forest sector. The employment impact of using recovered paper at U.S. paper mills in the late 1990s, for instance, was estimated to be 139,000 jobs at the mills alone, which at the time amounted to more than one in five jobs in the U.S. paper and paper products sector (Beck 2001, BLS 2014). Considering indirect and household impacts, the total employment effect of paper recycling was more than 750,000 jobs (Beck 2001). In addition, employment is created at companies that collect, sort and sell recovered paper.

The employment created in the collection and processing of recovered materials, including recovered paper, continues to grow. The European Environment Agency has observed that

"...overall employment related to materials recovery in Europe has increased steadily, from 422 inhabitants per million in 2000 to 611 in 2007, which is an increase of 45 %. Moreover, these figures are conservative, as they do not include employment linked to processing materials at certain manufacturing facilities, such as manufacture of pulp or metals" (EEA 2011).

A recent study undertaken for the European paper industry (Pöyry 2011) indicated that the value of expanding the use of biomass from energy generation only, to one with an array of pulp and paper products (including paper recycling), provided 7 times the job creation and 5 times the economic value to society. The study identified the pivotal role played by paper recycling, and increasingly by that of recovered wood products, in expanding the value chain of biomass use prior to energy generation and disposal.

In developed countries, paper collection and sorting is usually performed by a combination of public and commercial entities. While these operate as part of the formal economy, they tend to be large in number and of various sizes, making it difficult to collect basic information on their economic and social impacts (PITA 2010). In developing countries, wastepaper collection and sorting is even more diffuse, involving a combination of formal and informal activities, consisting of individuals and companies serving varying roles in the paper recovery process. In Pakistan, for instance, while wastepaper is often collected directly from large institutions, it is also collected from many dispersed sources by street hawkers and scavengers, many of whom are children 5 to 15 years of age who typically work 6 or 7 days a week (SEBCON 2012). For companies wanting to avoid child labor, this can pose considerable challenges as fiber is supplied by complex and long supply chains. It also must be acknowledged, however, that the economic value of these informal activities is considerable. In Buenos Aires, for instance, more than 40,000 waste pickers recover cardboard and other recyclables on the streets. Their economic impact is estimated at $178 million a year (Medina 2008).

The societal benefits of recovery and recycling extend beyond employment impacts. Citizen involvement in recycling activities, for instance, helps support an environmental ethic in society.

CERTIFICATION & TRACEABILITY

As an outgrowth of the forest products industry's wide adoption of third-party certified sustainable forest management, certification systems such as the Programme for the Endorsement of Forest Certification (PEFC 2014), the Forest Stewardship Council (FSC 2014), and the Sustainable Forestry Initiative (SFI 2014) have incorporated chain-of-custody systems for both fresh and recovered fiber. Forestry certification systems are intended to provide accurate and verifiable confirmation of the environmental attributes of the fresh fiber used in a finished product. Chain-of-custody systems provide added information beyond forestry certification regarding the fresh fiber supply origin. In addition, chain-of-custody systems provide assurance regarding the percent of certified fresh fiber or recycled content.

Given the complexities of quantifying and tracking fiber supply, these certification and chain-of-custody systems incorporate a detailed set of definitions and requirements, all of which are independently audited prior to achieving certification. Certification of fresh fiber provides information about the forests from which the fiber originated. Certification of recovered fiber is limited to confirming the amount of a given product that is pre-and/or post-consumer recovered fiber as it is not possible to determine whether this recycled fiber had its initial origin in a sustainably managed forest.

The increasingly global nature of the recovered fiber marketplace has led to new concerns about the transparency of information on the origin of recovered paper shipments that may be a component of broader, less regulated international trade in waste materials. Documenting the recovered fiber content of material sourced internationally can be addressed through chain-of-custody programs. However, while forest certification programs address concerns about the procurement of fresh fiber from “controversial sources”, the major certification programs do not currently contain provisions to address concerns about the lack of transparency in information on the origin of international shipments of recovered fiber.

Takeaways
Traceability of fiber

- Chain-of-custody certification verifies the traceability of fiber through the supply chain.
- Certification provides an independent assessment of the environmental and social attributes of the fiber used in the end product.
- Certification of fresh fiber provides information about forests from which the fiber originated.
- Certification of recovered fiber does not provide information as to whether the recycled content had its initial origin in a sustainably managed forest.

SELECTING A SUSTAINABLE PAPER PRODUCT

Takeaways
Making informed choices

- Sustainable sourcing decisions depend on multiple aspects, including legality, environmental and social factors.
- Choosing between fresh and recycled fiber is only one of many considerations.
- The Sustainable Procurement Guide for wood and paper based products provides additional insights and guidance to help make informed choices.

The decision to purchase sustainably produced paper and paperboard products requires attention to far more than the recycled fiber content (see Table 3). The Guide to Sustainable Procurement of Wood and Paper-based Products[3], issued jointly by WBCSD and the World Resources Institute (WRI) identifies the appropriate use of recycled fiber as only one of 10 key issues related to sustainable procurement of wood and paper products. The guide finds that

"Sustainable procurement can incorporate recycling in a number of ways, including using recycled content in paper and supporting measures to help the collection of recycled fibers in sufficient amounts to meet demand"

(WRI/WBCSD 2014b).

Sourcing and legality aspects		
1	Origin	Where do the products come from?
2	Information accuracy	Is information about the products credible?
3	Legality	Have the products been legally produced?
Environmental aspects		
4	Sustainability	Have forests been sustainably managed?
5	Unique forest values	Have unique forest values been protected?
6	Climate	Have climate issues been addressed?
7	Pollution	Have appropriate environmental controls been applied?
8	Fresh and recycled fiber	Have fresh and recycled fiber been used appropriately?
9	Other resources	Have other resources been used appropriately?
Social aspects		
10	Local communities and indigenous peoples	Have the needs of local communities or indigenous peoples been addressed?

Table 3: 10 key issues related to sustainable procurement of wood and paper-based products (WRI/WBCSD 2014b)

[3] For more information visit: www.sustainableforestproducts.org. The guide is a toolbox and resource kit designed to help corporate managers make informed choices, understand the challenges and find the best advice on how to purchase forest-based products from sustainable sources, be it paper or packaging, wood for construction or other forest products.

GLOBAL RECYCLING TRENDS

Takeaways
Positive impacts depend on recovery

- Positive impacts and effectiveness of recycling depend on how much usable fiber can be recovered.
- Global recovered paper demand is expected to grow by almost 3% per year on average while the utilization rate is projected to rise to 64% by 2028.

Paper fiber recovery and use can be characterized by the recovery rate (defined as the quantity of paper and paperboard collected for reuse divided by the total consumption of paper and paperboard) and by the utilization rate (defined as the total consumption of recovered paper divided by the total production of paper and board). On a global basis, both the recovery and utilization rates have steadily increased over time. In 2011, the world recovery rate was 57.3% and the world utilization rate was 56.8% (BIR 2013). However, when evaluated at a region-specific (or country-specific) scale there are sometimes short-term reductions in recovery and utilization rates even while long-term trends remain positive (BIR 2008 through 2013).

There are several paper and paperboard product categories for which recovery is not considered possible, e.g., hygiene and toilet products, papers used in some food/liquid packaging, products used in the building industry, etc. Furthermore, in some countries or regions the limits of what can reasonably be recovered are being approached, e.g., in Europe where collection volumes exceed local demand leading to increased exports (BIR 2013).

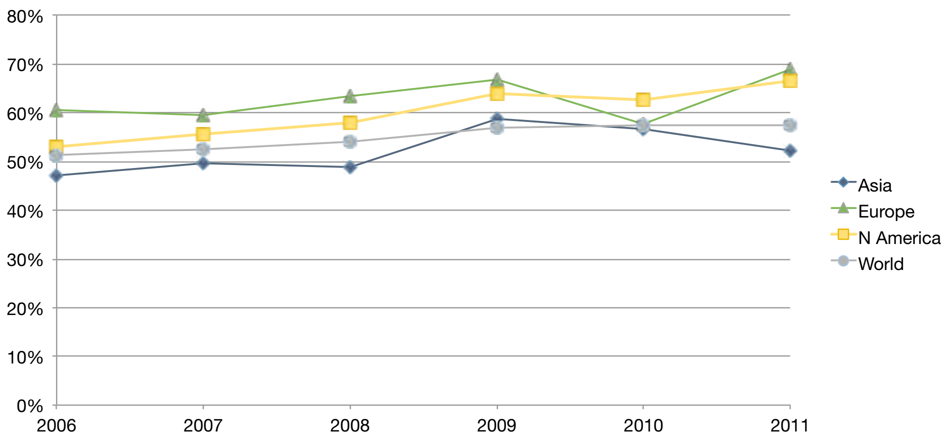


Figure 14: Fiber recovery rate by major world region, 2006 – 2011 (developed from data presented in BIR 2008-2013)

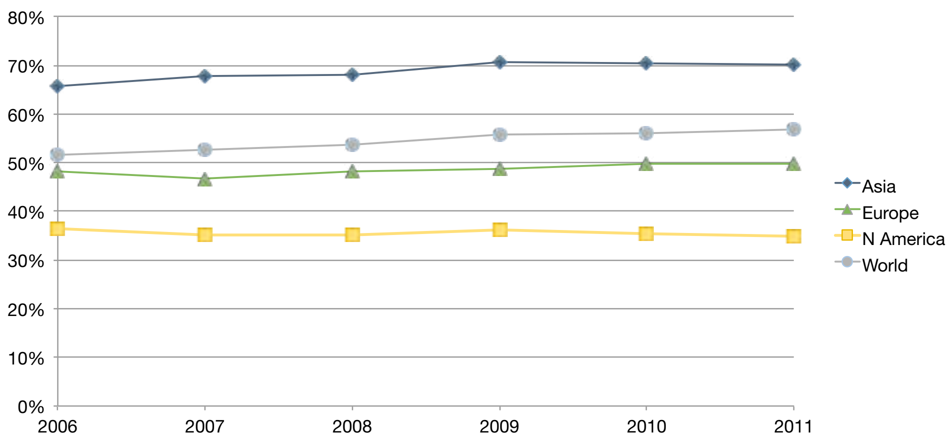


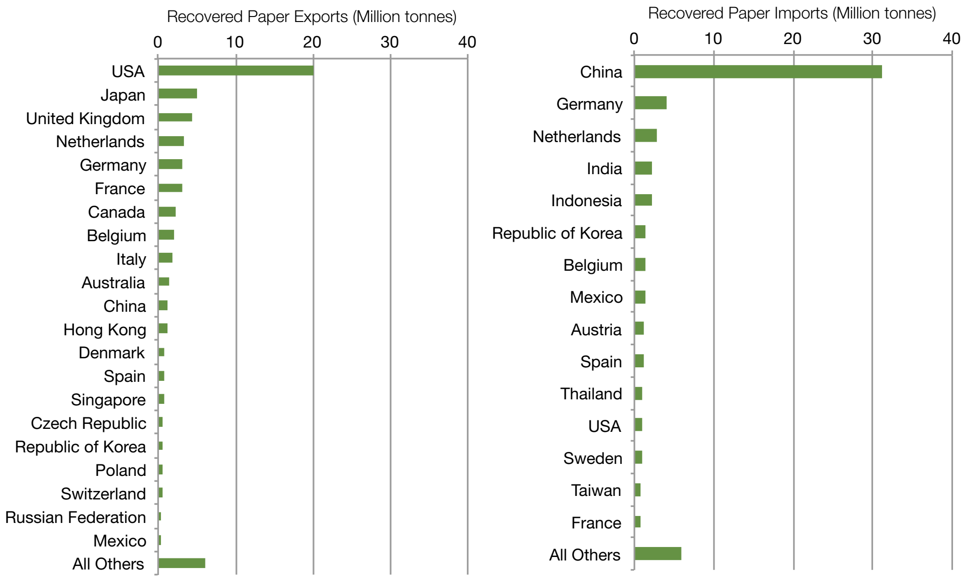
Figure 15: Fiber utilization rate by major world region, 2006 – 2011 (developed from data presented in BIR 2008-2013)

GLOBAL FLOWS OF RECOVERED FIBER

While about half the global pulp and paper industry's fiber supply is from recovered paper, there are significant differences in rates of recovery and use of paper between countries. This results in significant international trade in recovered fiber. While North America, Western Europe and Latin America are net exporters of recovered fiber, other areas, notably Asia, are net importers. Some countries, Germany for instance, are both significant importers and exporters of recovered fiber, reflecting the importance of specific recovered fiber types to the grades of paper and paperboard being produced in a country. The international trade of recovered paper amounts to 60 million tonnes, approximately 15% of the world's paper consumption in 2012 (FAOSTAT 2014).

North America recovered paper exports represented about 35% of total world exports in 2012, with the U.S. responsible for the majority. Canada changed from being a net importer of recovered paper to a net exporter in 2009; however, Canadian exports represent only about 7% of total North American exports. The ratio of North American net exports to total North American recovered paper collection rose from 17% in 2000 to 41% in 2012 (RISI 2013). OCC and mixed paper are the major recovered paper grades exported from North America. Western Europe is the other major recovered paper exporting region, with OCC being the primary grade exported.

Asia, and China in particular, is the major importing region of recovered fiber. Chinese recovered paper usage is forecast to grow by nearly 4% per year on average over the next 15 years; however, Chinese imports are predicted to remain flat or decline (RISI 2013). Of the Asian countries, Japan is the largest exporter in the region.



Figures 16a and 16b: Imports and exports of recovered paper (FAOSTAT 2014)

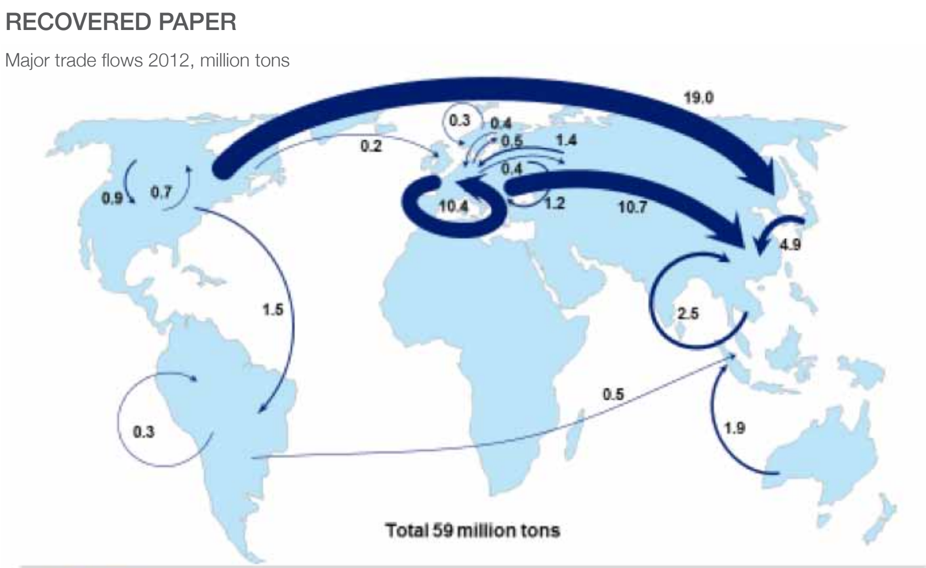


Figure 17: Illustrates the major trade flows of recovered paper in 2012 (Pöyry 2012)

North America and Western Europe, the two key recovered paper exporting regions, are expected to continue to ship significant quantities of recovered paper, with North America showing significant growth in net exports driven by the gap between its recovery rate and that in Western Europe (RISI 2013).

CONTINENTAL OUTLOOKS (2020/2030)

Over the next 15 years, global recovered paper demand is expected to grow by almost 3% per year on average while the utilization rate is projected to rise to 64% by 2028 (RISI 2013). Increases in the share of recycled fiber in the total fiber furnish will be restricted by forces such as rising collection/processing costs, loss of fiber quality and the quantities of recovered fiber that are rejected during processing, availability of relatively cheap fresh fiber in some regions, and growing demand for higher quality products from emerging economic regions. Figure 18 presents paper recovery rates (and projections) by major world region from 1980 through 2028 (RISI 2013).

In China, growth in recovered paper demand is predicted to slow from almost 15% per year during the period 1993 – 2010 to 3.8% per year on average in 2013 – 2028, due to limited opportunity to further increase the recycled fiber share in the total fiber furnish (RISI 2013). However, China is expected to remain the largest driver of global recovered paper demand growth. Asian net imports of recovered paper are expected to continue to grow although Chinese imports are predicted to remain flat or decline over the next 15 years as a result of increasing domestic recovered paper collection. In this region, Japan alone is a net exporter of recovered paper (Source of Asian imports figure: RISI 2013).

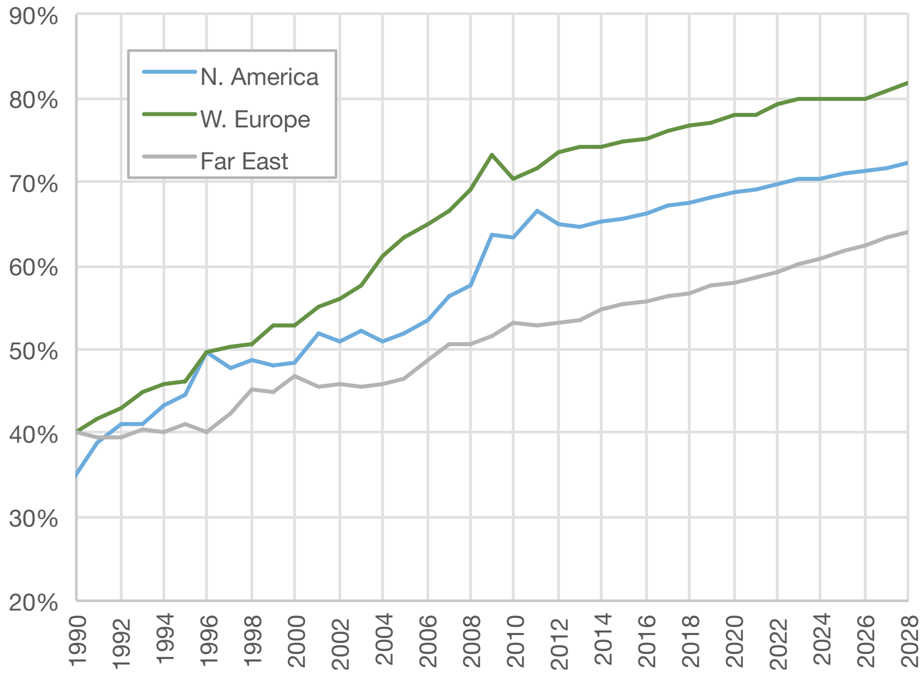


Figure 18: Paper recovery rates by major world region (RISI 2013)

Box 7: The pulp and paper industry is committed to increased use of recovered paper

- Confederation of European Paper Industries (CEPI) has already achieved a goal of a 70% "recycling rate" by 2015

- Japan Paper Association (JPA) has a goal of achieving a 64% utilisation rate by 2015.

- Paper Manufacturers Association of South Africa (PAMSA) has a goal of meeting a 63% recovery rate by 2017.

- American Forest and Paper Association (AF&PA) has a goal of attaining a 70% recovery rate by 2020.

- Forest Products Association of Canada has surpassed its goal of achieving a 55% recovery by 2012.

(ICFPA 2013)

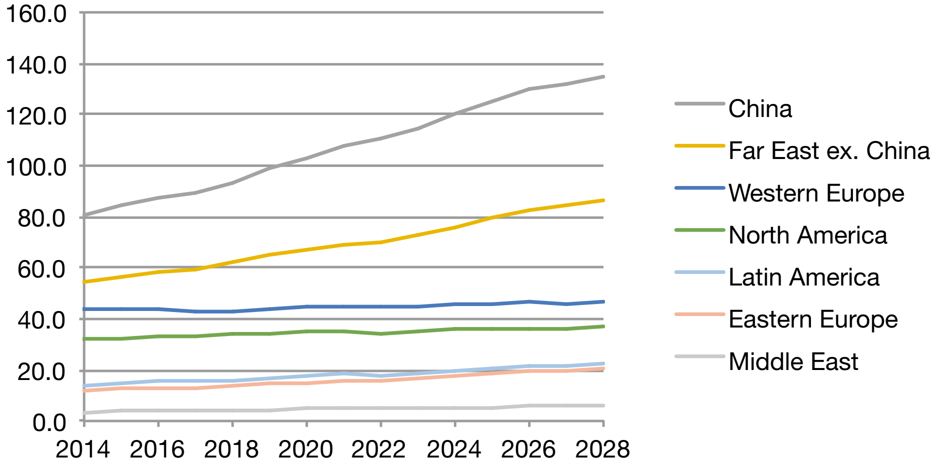


Figure 19: Projected recovered paper demand by region (million tonnes)

The quantities of paper recovered globally are projected to increase with the growth dominated by the Far East, primarily China (RISI 2013).

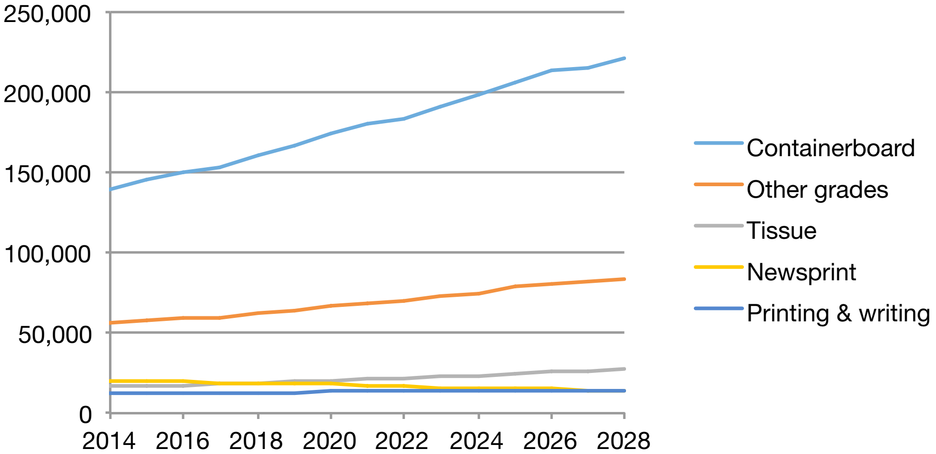


Figure 20: Projected recovered paper demand by type of product (million tonnes)

Growth in demand is projected to occur in all grades except newsprint, where declining production is expected to reduce the demand for recovered fiber. Likewise, due to moderating demand for printing and writing papers, demand for recovered fiber to produce these papers is expected to grow only slightly (RISI 2013).

Box 8: Major trends shaping the future of recovered fiber

- In developed countries, recovery rates for several grades of recovered paper, especially old corrugated containers (case materials) and newsprint are reaching practical maximums, although differences in recovery rates remain even among richer countries.

- Where recovered fiber is derived from grades of paper whose production is declining, lower quantities of recovered fiber are inevitable.

- Further gains in recovery rates will likely result in fiber that is more contaminated and of lower quality, especially where those gains are accomplished using comingled collection. This will increase the costs of using recovered fiber and challenge attempts to increase the recovered fiber content in the types of paper where the largest opportunities for increasing recovered fiber content remain e.g., graphic papers.

- Most of the increase in demand for recovered fiber will be from the Far East, China in particular, with the greatest growth in demand being for grades of recovered paper usable in containerboard (case materials) and packaging materials.

- While continued growth in paper recovery will offset some of the increased demand for paper fiber, fresh fiber production will also have to increase to provide the amounts and quality of fiber needed to meet global demand.

REFERENCES

Ackermann, C., L. Göttsching, H. Pakarinen. 2000. "Papermaking potential of recycled fiber. modeling of age distribution of RCF," in L. Göttsching H. Pakarinen (eds.), Recycled Fiber and Deinking, Papermaking Science Technology Series, Fapet Oy, Helskini, Ch. 10, 387-398.

American Forest and Paper Association (AF&PA). 2012. 2011 statistical summary. paper paperboard pulp, and annual AF&PA fiber survey. American Forest and Paper Association. Washington DC.

Beck, R.W. Inc. 2001. Final Report. U.S. Recycling Economic Information Study. Prepared for the National Recycling Coalition by R. W. Beck Inc http://www.epa.gov/osw/conserve/tools/rmd/rei-rw/pdf/n_report.pdf (accessed February 2015)

British Standards Institution (BSI). 2014. EN 643:2014 - Paper and board. European list of standard grades of paper and board for recycling. http://shop.bsigroup.com/ (accessed October 2014).

Bureau of International Recycling (BIR). 2008. The evolution of the recovered paper market: Comparing 2006 with 2005. (http://www.bir.org/industry/paper/recovered-paper-statistics/).

Bureau of International Recycling (BIR). 2009. The world recovered paper market in 2007. (http://www.bir.org/industry/paper/recovered-paper-statistics/).

Bureau of International Recycling (BIR). 2010. The world recovered paper market in 2008. (http://www.bir.org/industry/paper/recovered-paper-statistics/).

Bureau of International Recycling (BIR). 2011. The world recovered paper market in 2009. (http://www.bir.org/industry/paper/recovered-paper-statistics/).

Bureau of International Recycling (BIR). 2012. Recovered paper market in 2010. (http://www.bir.org/industry/paper/recovered-paper-statistics/).

Bureau of International Recycling (BIR). 2013. Recovered paper market in 2011. (http://www.bir.org/industry/paper/recovered-paper-statistics/).

Bureau of Labor Statistics (BLS). 2014. Databases, Tables & Calculators by Subject: Employment, Hours, and Earnings from the Current Employment Statistics survey (National): NAICS Code: 322. http://data.bls.gov/pdq/SurveyOutputServlet (access January 29, 2015)

Byström, S. and Lînnstedt, L. 1997. Paper recycling: environmental and economic impact. Resources, Conservation and Recycling 21(2):109-127.

Cederstrand, P., Riise, E. and Uihlein, A. 2014. Evaluation of recycling and allocation methods for paper. The Swedish Life Cycle Center report no 2014:1. Göteborg, Sweden: SCA Hygiene Products. http://lifecyclecenter.se/wordpressnew/wp-content/uploads/2014-04-01_Allocation-Methods-Report_2014_1.pdf (accessed 02 October 2014).

Christine Burrrow Consulting and Boxfish Group. 2011. Options for Increasing the Recovery of Paper Products in Canada. Environment Canada.

Confederation of European Paper Industries (CEPI). 2013. Key Statistics: European Pulp and Paper Industry 2013. Confederation of European Paper Industries. Brussels

Cullinan, H.T. 1992. The age distribution of recycled fibre. Appita. 45(1):6-8.

Endorsement of Forest Certification Schemes (PEFC). 2014. (accessed October 2014)

Ervasti, I. 2011. The limits of paper recycling, recover paper - basic definitions and unified approach. COST Action 48.

European Commission (EC). 2013. A new EU Forest Strategy: for forests and the forest-based sector. SWD (2013) 342 final, COM (2013) 659 final, SWD (2013) 343 final. Brussels: European Commission. http://ec.europa.eu/agriculture/forest/strategy/staff-working-doc_en.pdf (accessed October 2014).

European Commission (EC). 2014a. Biodegradable Waste website. http://ec.europa.eu/environment/waste/compost/ (accessed October 2014).

European Commission (EC) 2014b. Moving towards a circular economy. http://ec.europa.eu/environment/circular-economy/index_en.htm (accessed October 2014).

European Commission (EC). 2014 (Expected). For a European Industrial Renaissance. COM(2014) 14/2. Brussels: European Commission.

European Environment Agency (EEA). 2005. Paper and cardboard — recovery or disposal? Technical Report no. 5/2006. EEA.

European Environment Agency (EEA). 2006. Paper and cardboard — recovery or disposal? Review of life cycle assessment and cost-benefit analysis on the recovery and disposal of paper and cardboard. EEA Technical report No 5/2006. Pg. 10.

European Environment Agency (EEA). 2011. Earnings, jobs and innovation: the role of recycling in a green economy. EEA Report No 8/2011. Pg. 16.

Finnveden, G. and Ekvall, T. 1998. Life-cycle assessment as a decision-support tool--the case of recycling versus incineration of paper. Resources, Conservation and Recycling 24(3-4):235-256.

Finnveden, G. 2000. On the Limitations of Life Cycle Assessment and Environmental System Analysis Tools in General. International Journal of Life Cycle Assessment 5(4):229-238.

Food and Agriculture Organization of the United Nations (FAO). 2010. Recovered Paper Data 2009. http://www.fao.org/docrep/013/k9444e/k9444e00.pdf (accessed October 2014).

Food and Agriculture Organization of the United Nations (FAO). FAOStat, 2012. http://faostat.fao.org (accessed October 2014).

Food and Agriculture Organization of the United Nations (FAO). 2014. State of the World's Forests 2014. http://www.fao.org/forestry/sofo/en/ (Accessed January 2015)

Forest Stewardship Council (FSC). 2014. www.ic.fsc.org (accessed October 2014).

Göttsching, L., Pakarinen, H. (eds.) .2000. Recycled Fiber and Deinking, Papermaking Science Technology Series, Fapet Oy, Helskini.

Hardie, I., P. Parks, P. Gottleib, And D. Wear. 2000. Responsiveness of rural and urban land uses to land rent determinants in the US South. Land Econ. 76:659–673.

Institute of Scrap Recycling Industries (ISRI). 2014. Scrap Specifications Circular 2014. ISRI, Washington DC.

International Council of Forest and Paper Associations (ICFPA). 2013. 2013 ICFPA Sustainability Progress Report. www.icfpa.org (accessed October 2014).

International Organization for Standardization (ISO). 2006a. ISO 14040: Environmental management -- Life cycle assessment -- Principles and framework (Second.). Switzerland.

International Organization for Standardization (ISO). 2006b. ISO 14044: Environmental management — Life cycle assessment — Requirements and guidelines (First., p. 54). Switzerland.

International Organization for Standardization (ISO). 2012a. ISO 14047: Environmental management — Life cycle impact assessment — Illustrative examples on how to apply ISO 14044 to impact assessment situations (Second., p. 92). Switzerland.

International Organization for Standardization (ISO). 2012b. ISO 14049: Environmental management — Life cycle assessment — Illustrative examples on how to apply ISO 14044 to goal and scope definition and inventory analysis (Second., p. 56). Switzerland.

Lubowski, R.N., A.J. Plantinga, AND R.N. Stavins. 2008. What drives land-use change in the United States? A national analysis of landowner decisions. Land Econ. 84:529 –550.

Mantau, U. 2012. Wood flows in Europe (EU27) Project report. Celle 2012, 24 pp. published by the Confederation of European Paper Industries and the European Confederation of Woodworking Industries. www.cepi.org (accessed February 2015).

Medina, M. .2008. The informal recycling sector in developing countries. Gridlines Note No. 44. Published by the Public-Private Infrastructure Advisory Facility (PPIAF), Washington DC, October 2008. http://www.ppiaf.org/ (accessed October 2014).

Metafore. 2006. The Fiber Cycle Technical Document- Metafore Summary Report. March 2006 http://www.postcom.org/eco/sls.docs/Metafore-Paper%20Fiber%20Life%20Cycle.pdf (accessed October 2014).

Miranda, R., M.C. Monte, A. Blanco. 2013. Analysis of the quality of the recovered paper from commingled collection systems. Resources, Conservation and Recycling. Volume 72, March 2013, Pages 60–66.

National Council for Air and Stream Improvement, Inc. (NCASI). 2011. Summary of the Literature on the Treatment of Paper and Paper Packaging Products Recycling in Life Cycle Assessment. Technical Bulletin 0985. Research Triangle Park, NC: National Council for Air and Steam Improvement, Inc.

National Council for Air and Stream Improvement, Inc. (NCASI). 2012. Methods for Open-Loop Life Recycling in Life Cycle Assessment and Carbon Footprint Studies of Paper Products. Technical Bulletin No. 1003. Research Triangle Park, NC: National Council for Air and Stream Improvement, Inc.

Null, D. and L. Skumatz. 2004. Single Stream Recycling – Total Cost Analysis. Contained in “Paper Recycling: Quality is the Key to Long-term Success”. Published by American Paper and Forest Association (AF&PA). 2004. http://www.container-recycling.org/assets/pdfs/AFPA-PaperQualitySingleStream-3-04.pdf (accessed October 2014).

Paper Industry Technical Association (PITA). 2010. COST Action E48 – The Future of Paper Recycling in Europe: Opportunities and Limitations. Edited by Bartek Stawicki & Barry Read. Caric Press Ltd, Dorset.

Pöyry. 2012. Future from fibre: From forest to finished product. Published by WBCSD November 2012.

Pöyry. 2011. Employment and Value added – a comparison between the European pulp and paper industry and the bioenergy sector. Published by the Confederation of European Paper Industries (CEPI) http://www.cepi.org/system/files/public/documents/publications/forest/2012/FOR-142-11final.pdf (accessed October 2014).

RISI. 2013. World pulp and recovered paper 15-year forecast. Volume 13, Number 3. August, 2013.

Sacia, W. and J. Simmons. 2006. The effects of changing ONP quality on a newsprint mill. TAPPI Journal Vol 5 No. 1 pp 13-17.

Socio-Economic and Business Consultants (SEBCON). 2012. Child Labour in Wheat Straw and Recycled Paper Supply Chains. Available at www.storaenso.com (accessed October 2014).

Stürmer, L. and L.Göttsching. 1979. Physical properties of secondary fiber pulps under the influence of their previous history. Part 3: influence of the paper manufacturing process. Wochenbl. Papierfabr. 107(3):69-76.

Sundholm J. (editor) 1999. Mechanical pulping. Papermaking Science and Technology Series. Helsinki: Fapet Oy.

UNEP-SETAC-Life cycle initiative. 2009. Guidelines for Social Life Cycle Assessment of Products (p. 104).

Villanueva, A. and Wenzel, H. 2007. Paper waste - Recycling, incineration or landfilling? A review of existing life cycle assessments. Waste Management 27(8):S29-S46.

Wenzel, H. and Villanueva, A. 2006. The significance of boundary conditions and assumptions in the environmental life cycle assessment of paper and cardboard waste management strategies. An analytical review of existing studies. NorLCA.

World Business Council for Sustainable Development (WBCSD). 2014a. Action 2020 Priority Areas: Sustainable Lifestyles. http://action2020.org/priority-areas/sustainable-lifestyles (accessed October 2014) Geneva: World Business Council for Sustainable Development, 2014.

World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD). 2014b. Sustainable Procurement of Wood and Paper-based Products. An Introduction. Version 3.2 Update November 2014.

ANNEX 1: SOURCES OF INFORMATION FOR TABLE 1

The references listed below contain the source material used to derive the qualitative observations in Table 1. There are many factors that affect a mill's releases to the environment as well as its energy and wood requirements. One of these factors can be the use of recovered fiber. Studies examining the effects of using recovered fiber on mill-level performance come to varying conclusions depending on the specific circumstances and assumptions of each analysis. As a result, summary observations like those shown in Table 1, encompass a range of results.

AF&PA n.d. http://stats.paperrecycles.org/

Dence, C.W. and D.W. Reeve (eds.). 1996. Pulp bleaching: Principles and practice. Atlanta, GA: TAPPI Press.

Denison, R.A. 1996. Environmental lifecycle comparisons of recycling, landfilling and incineration:

A review of recent studies. Annual Review of Energy and the Environment 21: 191-237.

European Union BAT Reference (BREF). 2001. http://eippcb.jrc.es/reference/pp.html.

Finnveden, G. and T. Ekvall 1998. Life-cycle assessment as a decision-support tool—The case of recycling versus incineration of paper. Resources, Conservation and Recycling 24: 235-256.

Gottsching, L. and H. Pakarinen. 2000. Recycled fiber and deinking. Book 7 in Papermaking Science and Technology Series, ed. J. Gullichsen and H. Paulapuro. Helsinki, Finland: Finnish Paper Engineers' Association and TAPPI.

Hardie, I.W. and P.J. Parks. 1997. Land use with heterogeneous land quality: An application of an area base model. American Journal of Agricultural Economics 79(2):299-310.

Haynes, R.W., tech. coor. 2003. An analysis of the timber situation in the United States: 1952 to 2050. General Technical Report PNW-GTR-560. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

International Institute for Environment and Development (IIED). 1996. A changing future for paper. Prepared for the World Business Council for Sustainable Development. http://www.sustainable-finance.org/DocRoot/0KT94DCD0JMKDTaYmccj/paper-future.pdf.

Metafore. 2006. The fiber cycle technical document. Metafore summary report. http://postcom.org/eco/sls.docs/Metafore-Paper%20Fiber%20Life%20Cycle.pdf

Miner, R. and J. Perez-Garcia. 2007. The greenhouse gas and carbon profile of the global forest products industry. Forest Products Journal 57: 80-90.

National Council [of the Paper Industry] for Air and Stream Improvement, Inc. (NCASI). 1994. PCB and TCDD/F levels in effluents from deinking mills producing fine paper or tissue and toweling. Technical Bulletin No. 671. New York: National Council of the Paper Industry for Air and Stream Improvement, Inc.

National Council [of the Paper Industry] for Air and Stream Improvement, Inc. (NCASI). 2001. Factors that affect chloroform, AOX, chlorinated phenolic compounds, TCDD, and TCDF in kraft mill ECF bleach plant effluents–A literature review. Technical Bulletin No. 819. Research Park, NC: National Council for Air and Stream Improvement, Inc.

National Council for Air and Stream Improvement, Inc. (NCASI). 2004. Compilation of criteria air pollutant emissions data for sources at pulp and paper mills including boilers. Technical Bulletin No. 884. Research Park, NC: National Council for Air and Stream Improvement, Inc.

National Council for Air and Stream Improvement, Inc. (NCASI). 2011. Summary of the literature on the treatment of paper and paper packaging products recycling in life cycle assessment. Technical Bulletin No. 985. Research Triangle Park, NC: National Council for Air and Stream Improvement, Inc.

National Council for Air and Stream Improvement, Inc. (NCASI). 2012. Methods for open-loop recycling allocation in life cycle assessment and carbon footprint studies of paper products. Technical Bulletin No. 1003. Research Triangle Park, NC: National Council for Air and Stream Improvement, Inc.

Paper Task Force. 2002. http://epa.gov/climatechange/wycd/waste/downloads/EnvironmentalDefenseFund.pdf

Paulapuro, H. (ed.). 2000. Paper and paperboard grades. Book 18 in Papermaking Science and Technology Series, ed. J. Gullichsen and H. Paulapuro. Atlanta, GA: TAPPI Press and Finnish Paper Engineers' Association.

Pulp and Paper Research Institute of Canada (PAPRICAN). 2005. Benchmarking energy use in pulp and paper mills. Appendix 5 in The energy roadmap: Pulp and paper for a self-sufficient tomorrow:

An industry strategy. Natural Resources Canada.

Springer, A. (ed.) 2000. Industrial environmental control - Pulp and paper industry, 3rd ed. Atlanta, GA: TAPPI Press.

United States Environmental Protection Agency (USEPA). n.d. http://www.epa.gov/epawaste/nonhaz/municipal/msw99.htm.

United States Environmental Protection Agency (USEPA). n.d. http://www.epa.gov/msw/facts.htm

United States Environmental Protection Agency (USEPA). 1993. Proposed technical development document for the pulp, paper, and paperboard category effluent guidelines, pretreatment standards, and new source performance standards. Washington, DC: U.S. Environmental Protection Agency, Office of Science and Technology.

United States Environmental Protection Agency (USEPA). 1995. Compilation of air pollutant emission factors (AP 42). Volume I: Stationary point and area sources. Research Triangle Park, NC: United States Environmental Protection Agency Office of Air Quality Planning and Standards.

United States Environmental Protection Agency (USEPA). 1997. Supplemental technical development document for effluent limitations guidelines and standards for the pulp, paper, and paperboard category. Subpart B (bleached papergrade kraft and soda) and Subpart E (papergrade sulfite). EPA-821-R-97-011. Washington, DC: United States Environmental Protection Agency Office of Water.

United States Environmental Protection Agency (USEPA). 2005. Inventory of U.S. greenhouse gas emissions and sinks: 1990-2003. Washington, DC: United States Environmental Protection Agency.

United States Environmental Protection Agency (USEPA). 2006a. Final Report: Pulp, paper, and paperboard detailed study. EPA/821-R-06-016. Washington, DC: United States Environmental Protection Agency.

About WBCSD and the Forest Solutions Group

The World Business Council for Sustainable Development (WBCSD) is a CEO-led organization of forward-thinking companies that galvanizes the global business community to create a sustainable future for business, society and the environment. Together with its members, the Council applies its respected thought leadership and effective advocacy to generate constructive solutions and take shared action. Leveraging its strong relationships with stakeholders as the leading advocate for business, the Council helps drive debate and policy change in favor of sustainable development solutions.

The WBCSD provides a forum for its 200 member companies - who represent all business sectors, all continents and a combined revenue of more than $7 trillion - to share best practices on sustainable development issues and to develop innovative tools that change the status quo. The Council also benefits from a network of 60 national and regional business councils and partner organizations, a majority of which are based in developing countries.

The WBCSD Forest Solutions Group's (FSG) joins together global companies representing about 40% of forest, paper and packaging sales worldwide. The FSG is a global platform for forest-based companies and its value chain partners for strategic collaboration, to bring more of the world's forest under sustainable management and to expand markets for responsible forest products.

For more information visit www.wbcsd.org

About NCASI

The National Council for Air and Stream Improvement (NCASI) is an independent, non-profit research institute that focuses on environmental topics of interest to the forest products industry. Established in 1943, NCASI is recognized as a leading source of technical and scientific information on environmental issues affecting this industry. Although NCASI receives most of its funding from forest products companies, it also receives funding from government agencies, associations and other organizations interested in better understanding the connections between the forest products industry and the environment.

For more information visit www.ncasi.org

Disclaimer

This publication is released in the name of the WBCSD. The technical content was developed by NCASI under the commission of the WBCSD Forest Solutions Group. Like other WBCSD publications, it is the result of a collaborative effort by members of the secretariat and senior executives from the member companies. It does not mean that every company, NCASI or the WBCSD endorse every concept or approach described herein.

Project team

Prepared for the WBCSD Forest Solutions Group, led by Sustainable Value Chains & Procurement Solution Team,co-chaired by Neil Burns (Mondi) and Niek Stapel (AkzoNobel)

Technical input: Reid Miner, Kirsten Vice, Caroline Gaudreault, Brad Upton, Barry Malmberg and Chantal Lavigne (NCASI)

Working group:

3M: Dawn Krueger and Jean Sweeney

Akzo Nobel: Caterina Camerani and Niek Stapel

International Paper: Sophie Beckham and James McDonald III

Metsä: Paivi Makkonen

Mondi: Neil Burns, Peter Gardiner and Christian Ramaseder

Portucel Soporcel Group: Jose Luis Carvalho and Victor Coelho

Pöyry: Hannele Lehtinen and Petri Vasara

PwC: Bruce Eaket and Bruce McIntyre

SCG Paper: Montri Mahaplerkpong and Nakorn Manomayaanggoon

Suzano: Mike May

SCA: Stewart Begg

Unilever: Ruth Newsome

UPM-Kymmene: Timo Lehesvirta, Nina Norjama and Paivi Salpakivi-Salomaa

Weyerhaeuser: Rachael Jamison and Cassie Phillips

WBCSD Secretariat:

Matthew Reddy
Uta Jungermann

Photo credits: Fibria, Metsä, SCG Paper, StoraEnso & UPM.

wbcsd.org

World Business Council for Sustainable Development

Maison de la Paix, Chemin Eugène-Rigot 2,Case postale 246, 1211 Geneve 21, Tel: +41 (0)22 839 31 00

115 Fifth Ave, 6th Floor, New York, NY 10003

DLTA Complex, South Block, 1st Floor, 1 Africa Avenue, New Delhi 110 029, India, Tel: +91 11 3352 1527