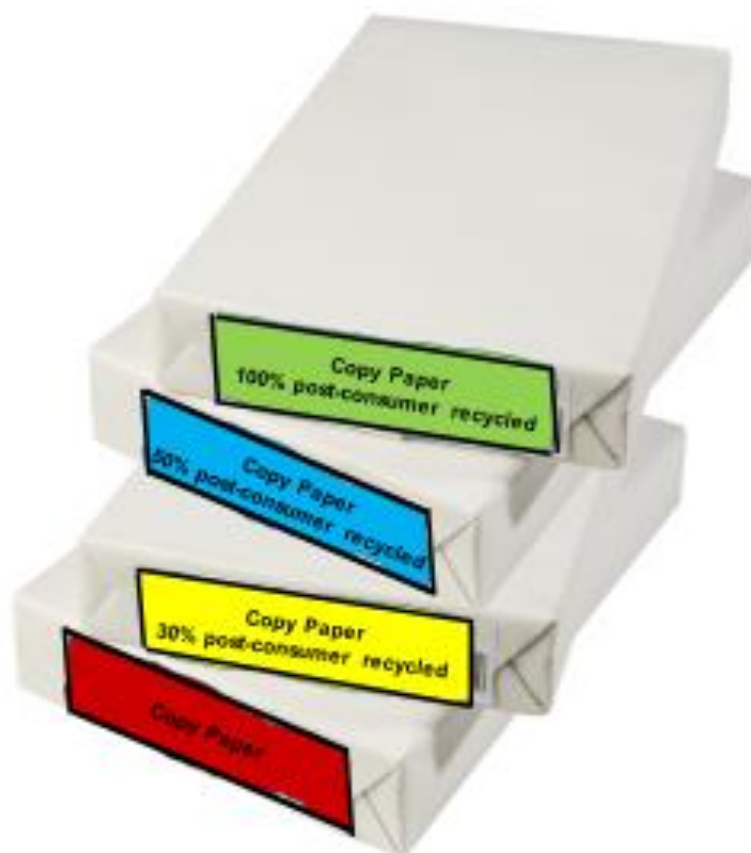


Selection of Printing and Writing Paper for Minimum Environmental Impact



Jim L. Bowyer

Gloria Erickson
Kathryn Fernholz
Harry Groot

Mark Jacobs
Ashley McFarland
Ed Pepke, Ph.D.

Dovetail Partners, Inc.

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Executive Summary

There are a number of types and grades of paper. Categories of paper products include printing and writing papers, newsprint, tissue and towel, containerboard (corrugated boxes and cartons), boxboard (cereal, and shoe boxes), and a host of specialty products. Within the printing and writing category are paper grades used for books, magazines, catalogs, brochures, calendars, business forms, commercial printing, and copy paper. Copy paper accounts for about half the volume of printing/writing paper produced annually.

Some paper products have relatively minimal requirements, requiring neither high strength nor unblemished appearance. At the other end of the spectrum are paper products requiring adherence to exacting standards for appearance and performance. Printing and writing papers, which include paper fed into desktop printers and office copy machines, sit at the top of the hierarchy.

Like paper products in general, production of printing/writing paper is both energy and water intensive, and requires large quantities of fiber – the vast majority of which is wood – as well as inorganic fillers. There is growing interest in lower impact paper products, and especially in high recycled content paper. In some circles there is also interest in non-wood based paper products, again inspired by desire to reduce the impacts of paper production. However, accurately identifying paper products with the lowest environmental impact can be a daunting task. Office supply stores and on-line vendors typically feature an extensive array of printing/writing paper. Recycled contents of displayed products range from zero to 100 percent, weights from 16 to 24 pounds¹, and fiber from wood to bagasse and sometimes even hemp and bamboo. Complicating matters is the reality that what may seem to be the obvious low impact product (such as 100% recycled content) is often far from the lowest impact option.

While selecting products with some level of recycled content is desirable, we conclude that moderation in demand for the level of recycled content, and insistence on post-consumer fiber exclusively, is advisable. Taking all factors into consideration, our view is that printing/writing paper with 10-30 percent recycled content – recycled content that includes pre-consumer waste – is what environmentally conscious consumers should be specifying in purchasing.

This report examines the environmental impacts of printing/writing paper and various aspects of environmental impact. Products are examined in a total system context, an essential requirement in identifying lowest impact products from among a number of possible choices.

¹ Measurement of weight varies by type and grade of paper. For copy paper, the basis for calculation of weight is 1,298.6 ft², the surface area of a ream (500 sheets) of paper. A universal measure of weight is grams per square meter of surface area, in this case 60-90 g.m².

Options Many, Identifying Lowest Impact Difficult

The paper which is loaded into the printer or copy machine is typically uniformly white, bright, opaque, tear resistant, and sufficiently stiff to prevent jamming – all engineered properties. It is also relatively inexpensive and readily available in the marketplace. Production of this paper is energy as well as water intensive, and wood, from harvest trees or byproducts of forest products manufacturing processes, is the principal raw material.

Awareness of the environmental impacts of producing paper, and the advantages of recycling, has stimulated consumer interest in products with high levels of recycled content. Recovery of paper for recycling has risen steadily worldwide over the past several decades², as has the average recycled content of paper products. But recycled content of various types of paper varies considerably, with newsprint and paperboard typically incorporating high percentages of recovered fiber, while recycled fiber use in other products is markedly lower. Printing and writing paper is at the low end of the scale with an average recycled content globally of 8% (Table 1).

Table 1
Average Percentage of Recycled Pulp Included in Several Paper Grades Globally

Paper Grade	% of World Production	Average % of Recycled Pulp
Paperboard, wrapping & packaging paper	57	56
Printing and writing paper	25	8
Sanitary and household tissue	8	34
Newsprint	6	68
Other (specialty)	4	27

Source: Haggith et al. (2018)

A wide variety of printing/writing paper products is available to consumers who have interest in reducing the environmental impacts of their consumption. Within office supply stores, increasing shelf space is devoted to high recycled content paper (typically 30, 50, and 100 percent), with such products generally promoted as ecologically better than lower recycled content options. A growing number of consumers are apparently willing to pay a premium for such paper. A recent check of recycled content paper in retail stores in the Minneapolis/St. Paul metropolitan area showed 30% and 100% recycled content paper selling at price premiums of 39% and 77%, respectively, compared to 0% recycled content paper with the same appearance and performance specifications. General purpose printing/writing paper with 50% recycled content was priced 57% more than comparable paper with 0% recycled content.

In seeking to inspire greater demand for recycled content paper, several organizations actively tout perceived environmental benefits of high recycled content products.³ One organization dedicated to increasing recycled content of paper has reported potential environmental benefits of producing printing/writing paper using 100% recycled fiber vs. 100% virgin fiber, including

² U.S. recovery of paper for recycling reached 68.1% in 2018.

³ Conservatree (2000), Kinsella (2012), Green America (2020), Environmental Paper Network (2018)

reduction of energy use, wastewater, and solid wastes of 31%, 53%, and 39%, respectively.⁴ Another report indicated lower impacts, and in some cases substantially lower impacts of 100% recycled vs. virgin fiber office paper⁵ in 15 of 16 categories of impact studied.⁶ While these findings are impressive, and would seem to indicate a clear imperative for purchase of 100% recycled fiber content printing/writing paper, the calculations on which both of these are based did not, unfortunately, consider potential impacts through the entire paper recovery and recycling system – an omission that is critically important to determining environmental advantage. Consequently, further consideration of the benefits of greater recycled content is needed. An additional environmental benefit of 100% recycled printing/writing paper that was asserted in the latter report was the potential savings of 24 trees per ton of paper. This too deserves a closer look.

Recycling

Categories of Wastepaper

Wastepaper is categorized by the type of paper, how it was collected, and whether the waste is pre- or post-consumer. For example, corrugated container waste is known as OCC (old corrugated container), and waste newspapers as ONP (old news print). A considerable volume of waste paper is classed as mixed paper, reflecting a shift in the United States toward single-stream recycling. The expanded practice of single-stream recycling has had the unfortunate effect of increasing the mixing of materials and introducing contamination of collected materials. In the process of single-stream collection involving paper, magazine papers, newspapers, copy and tablet paper, cereal boxes, and other types of papers become mixed in recycling collection bins, and mixed as well with metal, glass, and plastic of varying degrees of cleanliness. Such mixed paper has considerably lower value to recyclers.

Discarded printing and writing papers that are collected in dedicated sorting bins rather than being mixed with other types of paper constitute the most valuable waste paper. This type of waste, often collected by large businesses in relatively controlled office environments, goes to mills where it is re-pulped and de-inked in preparation for reuse in producing high quality products.

Paper that has been used at the final consumer level prior to being discarded and collected for recycling is classed as post-consumer waste. This accounts for the majority of waste paper. Pre-consumer waste includes trim or shavings from print shops, paper converting operations which cut large rolls of paper into usable sheets, magazine and book publishers that recycle unsold copies, and other categories of paper that never finds its way into the hands of final consumers. Pre-consumer waste is often collected without mixing with other types of paper, and is consequently of high value and suitable for recycling into the highest grades of paper.

⁴ Environmental Paper Network (2018)

⁵ The term “office paper” refers to all grades of printing/writing papers (copy paper, letterhead, forms, ledger paper) used in non-residential settings.

⁶ Paper Task Force (1995)

Environmental Benefits of Recycling

There is no question that recycling of paper fiber is environmentally beneficial. Use of recycled fiber in paper products reduces consumption of energy, water, and fiber. And, in general, recycling also reduces releases of pollutants to the atmosphere and generation of solid wastes.⁷ With regard to energy, savings associated with use of recovered vs virgin fiber at production mills can be as great as 70% for some grades of paper, and more modest (less than 30%) but nonetheless substantial for newsprint and some printing papers.⁸ Another benefit of recycling is that it reduces the volume of discarded paper sent to landfills which, in turn, reduces methane emissions from paper degradation.

Another often-listed advantage of paper recycling is that doing so reduces the need for timber harvesting thereby "saving" trees. The vision of saving trees is also a significant driver of the market for tree-free paper.

The idea that reduction in use of wood fiber will result in saving trees is somewhat analogous to a hypothetical situation in which a number of consumers decide to stop eating carrots in order to save them. Of course, in response to reduced consumer demand for carrots, farmers would simply stop planting carrots with the result that land on which they had been grown would be used for something else. With regard to wood fiber and forests, the result would be much the same. In short, a sustained reduction in harvested wood demand can counterintuitively result in both a reduction in forest area and fewer trees.

The fiber used in making paper in the U.S. comes almost entirely (89%) from privately owned forest land, with the majority of this in the southeastern region of the country where urban area expansion, vacation home development, and growing agricultural markets provide competition for forest land.⁹ Many forest landowners in this region rely on periodic harvests as a source of income. Income loss from reduction of harvests can tip the balance between retaining forest cover and selling land for alternative use. It is a problem that has been highlighted in a number of studies.¹⁰ This situation was realized a few years ago in Minnesota following divestiture of forest land by a major paper manufacturer in response to declining markets. Within a span of only a few months what had been several thousand acres of thriving northern spruce/ pine forest was cleared and the land converted to potato farming.¹¹

A downside of recycling is that whereas paper mills which produce paper from pulpwood operate largely or wholly on renewable energy obtained from raw material and pulping residues, recycling plants typically use natural gas as a power source. The result is that greenhouse gas emissions from paper recycling plants are often higher than from virgin paper mills.¹² At least one recycled paper producer uses renewable energy in its mills to overcome this problem.

⁷ Paper Task Force (1995), Otis (2016), Keränen and Retulainen (2016)

⁸ Chang and Pires (2015), Otis (2016)

⁹ Oswalt et al. (2019)

¹⁰ Sedjo and Botkin (1997), Lubowski (2007), McCraw (2014), Bowyer et al. (2014, pp. 14-15)

¹¹ Kennedy (2015)

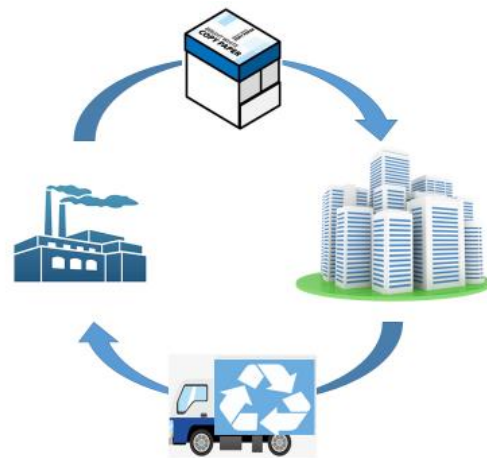
¹² Merrild et al. (2009), Thompson (2013, p. 21)

An Idealized Closed-Loop System

An idealized representation of 100% recycled copy paper is shown in Figure 1. In this scenario, newly manufactured paper goes from a paper recycling plant to large company or institution where it is used in copiers and printers, with all paper which is discarded on site collected for recycling and returned to the mill from which it came. In its simplest form the ideal is an endless loop of production, use, disposal and collection, and remanufacture.

The Figure 1 scenario assumes that all paper is collected for reuse, that there are no technical barriers to using all of the recovered printer/copy papers as reusable fiber for making new printer/copy paper, that inorganic fillers can be recovered and reused, and that there is no loss of fiber with repeated processing and use. These assumptions, however, do not reflect reality.

Figure 1
Idealized Copy Paper Recycling System



Recycling in Reality

The extent to which a given product can accommodate a high percentage of recycled fiber is largely dependent on performance requirements of the final product. Those products with the least demanding requirements can be made with high percentages of fiber that has been recycled multiple times, while those with more demanding requirements – such as printing/writing paper – are more limited in the extent to which recycled fiber can be used.

Wood fiber has a rather intricate structure, composed of several variously oriented layers of tiny sub-microscopic fibrils. In the manufacture of printing/writing paper, virgin fiber is produced by subjecting wood chips to strong chemicals which remove materials that serve to bond fibers together. Separated fibers are then processed to roughen surfaces and flatten the fibers for the purpose of increasing bonding potential in the finished paper sheet. One of the final steps is the addition of inorganic fillers such as calcium carbonate (25-30% by weight) for the purpose of filling microscopic voids in the paper surface in order to increase smoothness, brightness, and opacity.¹³

Recycling of fiber from a printing/writing grade paper involves collection and transport of used paper followed by fiber separation in large water-filled vats which act a bit like household blenders. Inorganic fillers are removed in this process, becoming sludge which goes to the landfill. The remaining mixture is then further processed through a series of screens and specialized equipment to remove contaminants. Ink which has been added to the paper must also be removed in preparation for fiber reuse. Each additional step adds cost. Moreover, fiber is degraded with each pass through the recycling process, with increased requirements for fiber cleaning resulting in greater degradation. Usable fiber loss with each reuse of newsprint fiber is illustrated in Table 2. Greater losses occur in processing of fiber for reuse in making

¹³ Wilson (2006)

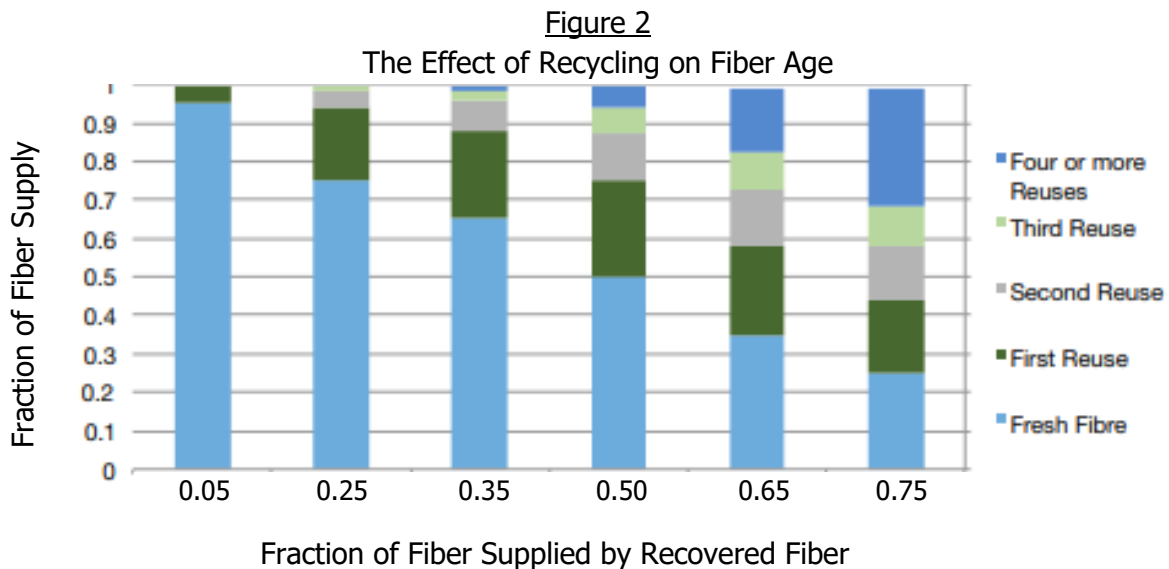
printing/writing paper grades. In general, including initial use, wood fiber can be used only four to seven times before its quality becomes too degraded for re-use. In the case of printing grades, the potential for repeated fiber reuse is at the low end of the scale.

Table 2
Recovered Fiber Yield with Repeated Recycling of Newsprint

Times recycled	Yield (%)
1	85
2	72
3	61
4	52
5	44
6	38

Source: Metafore (2006)

Given the problem of progressive fiber damage and yield loss with repeated recycling, fresh fiber must be introduced in each round of recycling. However, even when fresh fiber is added, the problem inherent in fiber reuse for products with demanding requirements is that fiber mixtures become highly degraded after only a few cycles of reuse. For example, a semi-closed loop system wherein recycled content is 75%, with 25% virgin fiber supplied each cycle to make up for fiber degradation and loss with each recycling, over 30% of the fiber will have been reused four or more times after four cycles of use and recycling (Figure 2). Eventually fibers degrade completely and are lost as fines.¹⁴



Source: World Business Council for Sustainable Development (2015)

For all of these reasons, only small quantities of recovered printing/writing paper fiber goes back into production of printing and writing paper. The vast majority of sorted office paper is recycled

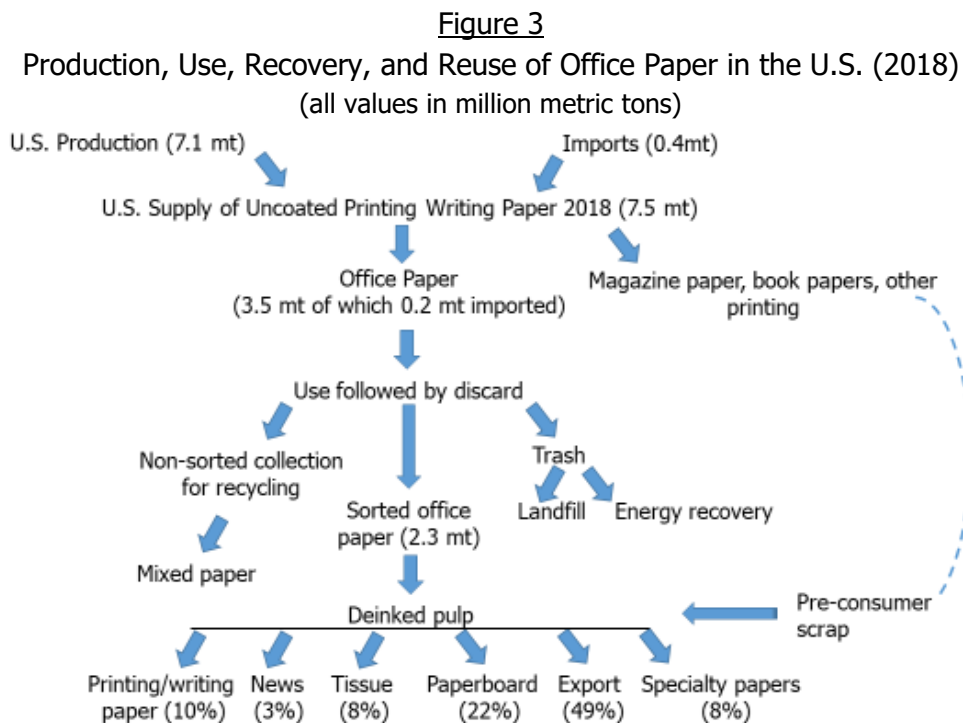
¹⁴ WBCSD (2015), Meinel et al. (2017)

into products other than office paper, such as tissue, paperboard, and specialty papers. Examples of high recycled content paperboard products include book covers, posters and poster board, greeting cards, and gift boxes. Exported pulp is used in making similar products in destination countries.

By reusing fiber in successively less demanding products (sometimes referred to as cascading use), the useful life of a fiber can be significantly extended.¹⁵ Conversely, attempting to salvage and clean recovered fiber to the point that it can be reused in making printing and writing grades of paper is likely to significantly shorten fiber life.

The U.S. flow of office paper production, use, discard, recovery and disposal in 2018 is illustrated in Figure 3. A portion of office paper, the majority of which is copy paper, is collected as shredded, sorted office paper, deinked, and then subsequently used in producing paper products that require bleached high quality pulp. Some of this fiber is used in making recycled content printing/writing paper. Copy paper deposited into home recycling bins almost always becomes part of single-sort recycling systems, thereby becoming relatively low value mixed paper.

A broader look at U.S. paper production and flows similarly illustrates cascading. Just as with recovered office paper, only a small portion of recovered newsprint and paperboard is used in making new newsprint and paperboard, while considerable quantities of fiber are diverted to production of cereal boxes and similar products which typically contain 100% recycled fiber (Figure 4).

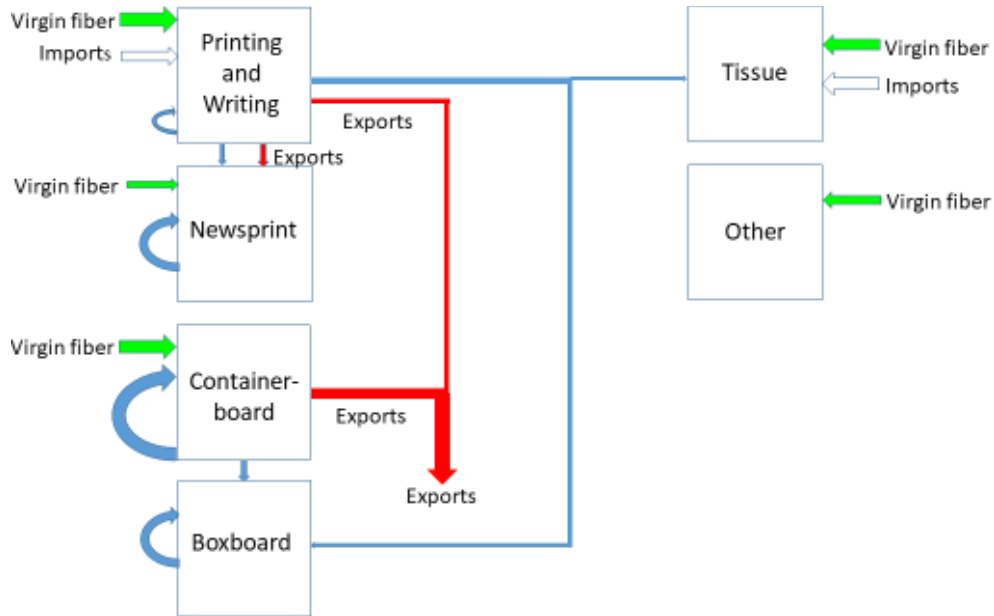


Source: Based on FAOSTAT (2020), Moore (2018, 2019), and other sources.

¹⁵ Hill (2011)

Figure 4

Simplified Representation of Fresh and Recovered Fiber Inputs and Flows in the U.S. Paper and Paperboard Industry



Source: Graphic based on WBCSD (2015) Figure 11, and AF&PA data (2020).
(The width of the arrows indicate relative volumes of fiber)

Industry-wide, fiber from recovered paper is used as shown in Table 3.

Table 3
Uses of Recovered Fiber in U.S. Paper and Paperboard Industry (2017)

Paper/Packaging Type	Thousand Tons Recovered	Share of Total (percent)
Tissue	4,409	8.4
Containerboard	19,082	36.2
Boxboard	6,073	11.5
Newsprint and other*	2,943	5.6
Net exports	20,170	38.3
Total	52,676	100.0

*Other includes printing/writing, kraft packaging and industrial converting, construction paper and board, and molded pulp.

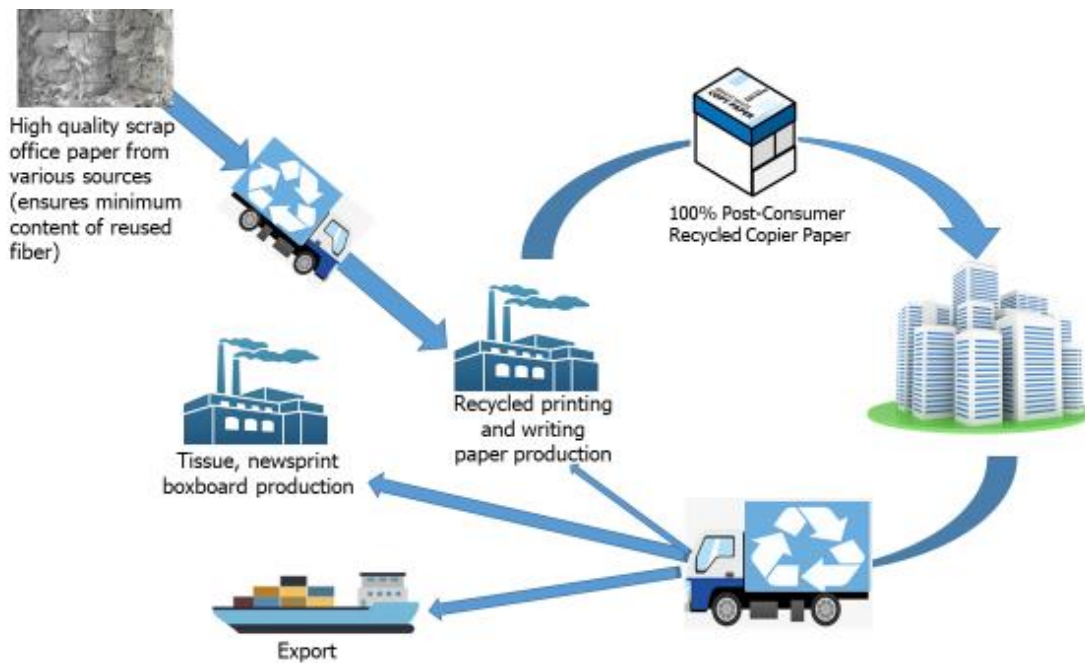
Source: American Forest and Paper Association (2020)

Taking into account all of these factors, paper recycling looks far different than the idealized view illustrated in Figure 1. In reality a 100% recycled mill operation looks more like Figure 5.

To provide 100% recycled content printing/writing paper, such as copy paper, over an extended period, requires that the manufacturer continually seek diverse sources of high quality printing/writing paper waste to help to minimize the presence of fiber that has been previously reused. This means that instead of a closed loop, the production system is in reality an open loop

or semi-closed loop in which a paper manufacturer might buy all recovered paper of its customers, resell this recovered paper to entities producing paper products with less demanding requirements, then supply customers with new recycled content paper made from new waste paper obtained elsewhere.

Figure 5
Simplified Representation of 100% Recycled Copy Paper
Production, Use, and Discarded Paper Recycling



Assessment of High Recycled Content Printing/Writing Paper from a Systems Perspective

Calculation of energy savings and reduction of wastewater production, solid wastes, and fresh fiber consumption with high recycled content paper products, in comparison to low or no recycled content, is problematic unless calculations consider effects throughout the fiber system.

An example of this is provided by an analysis of the effect of changing fiber flows from the normal hierarchy of use (office paper → tissue/newsprint/paperboard/specialty papers → boxboard) to a system in which additional volumes of waste printing and writing paper are recycled into more of the same type of paper. Illustrated in Table 4 are two scenarios of recovered paper use through one cycle of fiber reuse. The baseline scenario represents U.S. paper industry practice in 2006. Volumes of various types of paper recovered, combined with yield losses encountered in processing of fiber for reuse, resulted in 33.4 million tons of reusable fiber for recycling. In this scenario only minor volumes of printing/writing paper are used to produce more printing/writing paper. Shown in the blue shaded columns (right side of Table) is an alternative scenario in which all recovered waste printing/writing paper (approximately 7.2 million tons) is shifted from production of newsprint, tissue, and other grades to production of printing and writing grades. The shift yields an additional 5 million tons of usable fiber for printing and writing paper

production (after accounting for fiber loss in processing) as well as an increase in recycled content of printing/writing papers. However, the result is a loss of 6.7 million tons of reusable fiber for secondary use and a net loss of usable fiber of over 872,000 tons. This, in turn, increases the overall need for virgin fiber inputs to products other than printing/writing paper. Extending this analysis beyond one cycle would result in even greater overall fiber loss in printing/writing paper production.

In the alternative scenario, the additional fiber sent to printing/writing paper production could be used to produce quantities of 100% recycled paper or to increase the average recycled content of paper produced from about 7% to 28%. It is important to note that use of all recovered fiber to produce 100% recycled printing/writing paper would require that most printing/writing paper produced would contain no recycled content.

Table 4
Comparison of Two Scenarios of Printing and Writing Paper Production

	Yield Loss	Baseline Scenario		Shift of Additional Fiber to Printing and Writing Paper Scenario		Material Effect
		Recovered Paper Use	Reusable Fiber	Recovered Paper Use	Reusable Fiber	Net Change
All values in short tons						
Printing/writing	30%	1,926,562	1,348,594	9,069,189	6,348,432	4,999,838
Newsprint	15%	4,543,413	3,861,901	4,251,680	3,613,928	-247,974
Tissue	25%	4,033,172	3,024,879	1,128,132	846,099	-2,178,781
Other	12%	28,563,312	25,135,174	24,647,373	21,689,689	-3,446,026
Total		39,096,373	33,392,028	39,096,373	32,498,147	-872,942

Source: Metafore (2006)

A mid-1990s European-focused study of environmental impacts of various levels of recycled content employed early application of life cycle assessment in examining this issue.¹⁶ This study found that forcing high recycled content (such as through legislative and policy mandates) had the effect of dramatically increasing environmental impacts for much the same reasons as illustrated in the previous example.

The International Institute for Applied Systems Analysis (IIASA) also examined recycling programs and initiatives in a European context.¹⁷ The final report included the observation that while closed-loop recycling is a popular goal of planners, it is important to view recycling systems holistically, taking into account the facilities and activities required for managing recycling, overall energy consumption, and the need to add material to compensate for quality degradation. It was noted that without diligence in designing recycling systems, recycling can actually have the effect of increasing demand for resources – the opposite of the intended effect.

¹⁶ Byström and Lönnstedt (1997)

¹⁷ Virtanen and Nilsson (1993)

In 2019, a U.S.-focused, life cycle assessment was initiated by the U.S. paper industry.¹⁸ That assessment, which will examine the entire global paper cycle, is designed to provide up-to-date answers regarding whether adding more recycled content to products always better from an environmental perspective.

In practice, product yields and performance requirements, along with economics, dictate how much recovered fiber is used in making each type of paper.

As more definitive answers are awaited from this latest study, evidence to this point suggests that high recycled content printing/writing paper (i.e. 50-100% recycled content) does not automatically correlate to environmental benefit. Further, while there are many advantages of paper recycling, this reality does not necessarily mean that recycling fiber recovered from each type of paper product back into more of the same type of product yields the lowest environmental impact. In fact, findings indicate that pursuing these strategies could lead to an *increase* rather than reduction of environmental impacts.

Our view is that printing/writing paper (including copy paper) with 10-30 percent recycled content – recycled content that includes pre-consumer waste – is what environmentally conscious consumers should be purchasing. We would also advise that printing/writing paper with higher percentages of recycled content be avoided.

Environmentally Preferable Recycled Content

From a manufacturing perspective, recycled content is determined by the recovery rate (the volume of collected wastepaper available for recycling), and processing loss (the portion of fiber lost in the process of recycling). Costs of processing, which include fiber and energy costs, are also part of the equation.¹⁹

Fiber allocation is also driven by consumer demand. Strong markets for recycled content paper, coupled with consumer willingness to pay more for recycled content products, can incentivize greater use of recovered paper in paper products production, as well as production of product lines with very high recycled content. By the same token, consumer demand for post-consumer fiber content exclusively can also influence manufacturers to practice less efficient resource allocation and to produce products with greater environmental impact than they normally would.

Our conclusion is that selecting products with some level of recycled content is desirable since it reduces landfill disposal and related methane emissions, and can help to incentivize research to develop technologies for extending fiber life. We also observe that a singular focus on post-consumer content leaves no room for recycling of printer trimmings or production overruns (pre-consumer waste) when the reality is that these things are a fact of life that result in recyclable paper that should also be diverted from waste streams. Taking all factors into consideration, our

¹⁸ Kozlowski (2019)

¹⁹ Thompson (2013)

view is that printing/writing paper with 10-30 percent recycled content – recycled content that includes pre-consumer waste, is what environmentally conscious consumers should be purchasing. We would also advise that printing/writing paper, including copy paper, with higher percentages of recycled content be avoided.

Tree-Free Paper

There are environmental impacts associated with the production of all papermaking raw materials and their subsequent conversion to paper. Systematic analyses of these impacts reveal that environmental impacts associated with production of non-wood fiber vary considerably depending upon the fiber source involved. While it is widely perceived that annual yields of intensively managed agricultural fiber crops are higher than annual production in forest plantations or naturally managed forests, this is not necessarily the case. Comparisons made to yields of southern pine planted within the last two decades shows pine fiber yields over the course of 20 to 30 years to be comparable to or even higher than total cumulative fiber yields from annual fiber crops. What this means is that a single forest crop, involving no more than 6-8 stand treatments, can produce similar volumes to a series of annual crops on an equivalent land area which require 200-400 treatments involving mechanical equipment and chemical application.²⁰

A 2014 Dovetail investigation of relative impacts of wood-based and tree-free fiber (see link below) found that tree-free paper is not benign from an environmental point of view, nor in most cases environmentally better than paper made of wood. It was also determined, as indicated in the recycled content discussion, that markedly reducing wood fiber as a papermaking raw material would likely lead to fewer trees and a smaller area of forested land than is now in existence.

For a detailed discussion of tree-free paper, visit Bowyer et al. (2014).

(https://dovetailinc.org/report_pdfs/2014/dovetailtreefree0714.pdf).

Recommendations

To minimize the environmental impacts of printing/writing paper we recommend that:

- Purchases of printing/writing paper be restricted to a maximum of 30% recycled content, with recycled content to include pre-consumer fiber.
- Tree-free paper product purchases be carefully considered.
- Businesses be encouraged to practice sorting of clean waste office paper from general office trash as part of an overall office recycling plan (<https://cleanriver.com/set-office-recycling-program/>).
- Local community governments be urged to encourage source separation of copy and other printing and writing paper through scheduling of semi-annual document shredding events.

²⁰ Bowyer et al. (2014)

Summary

Calculations of environmental benefits that can be obtained through greater levels of recycled content in printing and writing papers, including copy paper, commonly omit consideration of potential impacts throughout the national and global paper fiber system. It is a critically important omission that can result in misleading conclusions about the benefits of increased use of recycled fiber at the top of the fiber use cycle.

Research to date indicates that attempts to close the fiber cycle in the highest quality paper products has the effect of reducing fiber reuse potential throughout the fiber cycle, potentially triggering greater virgin fiber demand and an overall increase in environmental impacts.

While selecting products with some level of recycled content desired, moderation in demand for the level of recycled content, and in insistence on post-consumer fiber exclusively, is advisable. Taking all factors into consideration, our view is that printing/writing paper with 10-30 percent recycled content – recycled content that includes pre-consumer waste, is what environmentally conscious consumers should be purchasing.

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