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Sanitary Paper Standard (GS-1) Revision Background Report

Call for Public Comment

March 27, 2025. Green Seal® is inviting feedback on proposed revisions to the GS-1 Standard for Sanitary Paper Products. We are seeking comments from all stakeholders including industry experts, public health researchers, product designers, raw material suppliers, product testing laboratories, purchasers, end users, and the public. To learn more or submit comments, please visit our Sanitary Paper Standard Revision page.

Summary of Proposed Revision:
This revision modernizes the standard's health and environmental criteria to ensure they align with market needs as well as new sustainability opportunities for the product category. Proposed revisions include:

- Adjusting the PCR requirements to align with the Environmental Protection Agency (EPA) Comprehensive Procurement Guidelines.
- Adding a pathway for sustainably sourced bamboo products.
- Creating a designation for 100% recycled products.
- Adjusting the chlorine-free bleaching requirements for alternative fibers (e.g., agricultural residue and bamboo).
- Prohibiting the intentional addition of PFAS as a functional papermaking additive.
- Adding Environmental Management System (EMS) requirements.
- Removing the basis weight requirements.
- Updating test methods referenced in the performance testing requirements.

Green Seal® is the leading U.S. ecolabel, symbolizing transparency, integrity, and proven environmental leadership. We develop life-cycle-based standards and certify products and services that can prove they meet our strict criteria for human health, reduced environmental impacts, and effective performance. Operating as a nonprofit since its founding in 1989, Green Seal has certified thousands of products and services in over 450 categories, and is specified by countless schools, government agencies, businesses, and institutions.

Table of Contents

Section I. Instructions for Submitting Comments

At Green Seal we believe that a collaborative approach leads to better solutions for everyone. We develop standards through an open, transparent process that prioritizes stakeholder input. Public comment periods are a mechanism for soliciting input and promoting the effectiveness of our proposed criteria toward achieving our intended outcomes.

Guidelines for Submitting Comment
Comments should,

- Be specific in nature.
- Include a technical or market-focused justification.
- Include references from reputable sources.
- Include actionable solutions.

Public Comment Closing Date
This comment period is open for 30 calendar days. The comment period closes on April 28, 2025.

Submit Comments via Green Seal's Website
Comments must be submitted online. The submission form can be found here, or on our standard project page.

Comment Review Process
Upon receiving comments, Green Seal will confirm receipt and may reach out to schedule a brief conference call to request clarification.

Within 90 days of the close of the comment period, Green Seal will publish a Response to Comments document which includes the text of all written comments submitted during the Public Comment Period and summarizes actions taken as well as justifications for inaction regarding the changes to the standard.

For Questions About This Process

For other inquiries, contact our team at standards@greenseal.org.

Section II. Proposal Overview

In 2023, Green Seal performed a review of its Standard for Sanitary Paper Products (GS-1) criteria that involved a market scan, outreach to stakeholders, and environmental impacts research. As a result, we devised several updates to the standard, including an allowance for products made from 100% bamboo, and changes to the post-consumer recycled content, performance testing, and low-impact manufacturing requirements.

Below is a brief summary of each of the proposed revisions:

Adjustment to the Post-Consumer Recycled (PCR) Content Requirements. In the revised version, we propose adjusting the post-consumer recycled content requirements to align with the Environmental Protection Agency (EPA) Comprehensive Procurement Guidelines. These adjustments promote harmonization and acknowledge supply challenges for PCR content.

Addition of a Pathway for Sustainably-Sourced Bamboo Products. In the revised version, we propose adding a pathway to the standard for sustainably-sourced bamboo products to expand certification pathways while still providing clear environmental benefits.

Creation of a Designation for 100% Recycled Products. In the revised version, we propose creating a designation for products that meet the 100% recycled content and PCR requirements. This designation will help purchasers easily identify certified products made from recycled content.

Updates to the Chlorine-Free Bleaching Requirements for Alternative Fibers. In the revised version, we propose adjusting the chlorine-free bleaching requirements for alternative fibers given market feasibility.

Prohibition of Per- and Polyfluoroalkyl Substances. In the revised version, we propose prohibiting the intentional addition of PFAS as a functional papermaking additive as part of Green Seal's work to address PFAS as a group of hazardous chemicals across all product categories.

Changes to the Low-Impact Manufacturing Requirements. In the revised version, we propose codifying our existing Good Manufacturing Practices (GMP) requirements to increase transparency and adding additional Environmental Management System (EMS) requirements.

Changes to the Performance Testing Requirements. In the revised version, we propose removing the basis weight requirements, updating the referenced test methods for tensile strength and stretch, and adjusting the thresholds for dry tensile strength and stretch to better reflect accurate performance for this product category.

Intended Outcomes

Reducing Carbon Emissions and Preserving Forests

Sanitary paper products such as toilet paper, paper towels, and facial tissues are essential items used at home and work each day. These products are typically used only once before being thrown or flushed away. Pulp used to make these products can come from several sources, including wood (virgin fiber), recycled content, and alternative fibers such as bamboo. The fiber composition of these products has a significant impact on their overall environmental footprint. For example, products made from virgin fiber can generate three times as many CO_2 emissions as products made from other types of pulp.[1]

Using recycled content in sanitary paper products results in lower greenhouse gas emissions[1] because it eliminates the emissions associated with extracting and manufacturing virgin materials. Collecting and re-processing recycled content (paper products that have been diverted from waste streams) also results in reduced carbon emissions across the product lifecycle. In particular, recycled content has reduced carbon footprints because they preserve forests[2] — which serve as carbon sinks — and divert materials from landfills where discarded products emit methane, a potent greenhouse gas.

When sustainably sourced, alternative fibers like bamboo can also help preserve forests and can reduce the carbon footprint of sanitary paper products compared to using virgin forest fiber.[3,4] Thus, Green Seal's standard sets forth requirements to ensure certified products contain recycled content or sustainably sourced alternative fibers (agricultural residue or bamboo) and do not contain any virgin forest fiber.

Reducing the use of Forever Chemicals

So called "forever chemicals", PFAS do not naturally biodegrade in the environment, and thus are problematic throughout the product life cycle, from production to use and disposal.[5] A 2023 study by USGC tested both private and government-regulated public water supplies across the nation and found that at least 45% of tap water sources are estimated to have one or more PFAS contaminants.[6] Researchers anticipate that certain PFAS are likely to take centuries to fully degrade, so the contaminant levels are only expected to continue increasing without any regulatory or

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[1] NRDC: The Issue With Tissue: How Americans are Flushing Forests Down the Toilet. https://www.nrdc.org/sites/default/files/issue-tissue-how-americans-are-flushing-forests-down-toilet-report.pdf
[2] Fourth National Climate Assessment: Chapter 6 – Forests. https://nca2018.globalchange.gov/chapter/6/
[3] Assessment of Alternative Fibers for Pulp Production. https://bpb-us-e1.wpmucdn.com/sites.gatech.edu/dist/a/1473/files/2024/08/Alternative-Fiber-LCA_Public-Report-FINAL-01-14.pdf
[4] Life Cycle Assessment Comparing Ten Sources of Manmade Cellulose Fiber. https://www.scsglobalservices.com/resources/full-report-new-lca-study-compares-10-fiber-sources
[5] Disposal of products and materials containing per- and polyfluoroalkyl substances (PFAS): A cyclical problem. https://doi.org/10.1016/j.chemosphere.2020.127659
[6] Tap Water Study Detects PFAS 'Forever Chemicals' Across the US. https://www.usgs.gov/news/national-news-release/tap-water-study-detects-pfas-forever-chemicals-across-us

voluntary action to reduce the usage of these chemicals.[7] PFAS are released into the environment from industrial sites, airports, military bases, landfills, and water treatment plants, as well as from the use of consumer products. Thus, PFAS are found in ecosystems around the globe and are known to bioaccumulate in plants and animals.[8,9] Removing PFAS from supply chains and ensuring that they are not in consumer products will slow and prevent additional environmental contamination.

Exposure to PFAS has been associated with serious health effects, including thyroid dysfunction[10]; altering hormone production and menstruation[11]; increased risk of certain cancers[12]; and impacting immunological processes, including reduced immune response to vaccinations.[13] Negative health outcomes have affected vulnerable populations such as children and women who are pregnant. Nearly all Americans have measurable levels of PFAS in their blood.[14] Health risks associated with long-term exposure in communities with PFAS contamination in drinking water sources is well documented.[6,] Eliminating PFAS as a chemical class from products will reduce people's exposure and therefore reduce the likelihood of negative health outcomes.

As part of Green Seal's work to address PFAS as a group of hazardous chemicals across Green Seal product categories,[15,16] PFAS will be prohibited in functional papermaking additives used to produce certified products.

[7] Investigation of the Biodegradation Potential of a Fluoroacrylate Polymer Product in Aerobic Soils https://doi.org/10.1021/es0710499
[8] Perfluorinated compound (PFC) concentrations in northern gannet eggs 1977-2014: a Predatory Bird Monitoring Scheme (PBMS) report. https://pbms.ceh.ac.uk/sites/default/files/PBMS_Gannet_PFCs_report_2013.pdf
[9] Plant uptake and translocation of perfluoroalkyl acids in a wheat-soil system. https://pubmed.ncbi.nlm.nih.gov/30178412/
[10] Thyroid Disrupting Effects of Old and New Generation PFAS. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7851056/
[11] PFAS and female reproductive outcomes: PFAS elimination, endocrine-mediated effects and disease. https://www.sciencedirect.com/science/article/pii/S0300483X2100353X
[12] What are the health effects of PFAS? https://www.atsdr.cdc.gov/pfas/health-effects/index.html
[13] Serum vaccine antibody concentrations in children exposed to perfluorinated compounds. https://doi.org/10.1001/jama.2011.2034
[14] ATSDR, Understanding PFAS Exposure and your Body. https://www.atsdr.cdc.gov/pfas/health-effects/PFAS-exposure-and-your-body.html#:~:text=Nearly%20all%20people%20in%20the,carpeting%20and%20water%20repellent%20clothing
[15] Prohibiting PFAS Chemicals. https://greenseal.org/prohibiting-polyfluorinated-chemicals-call-for-comment/
[16] Eliminating PFAS from the Supply Chain for Consumer Products. https://greenseal.org/eliminating-pfas-from-the-supply-chain-for-consumer-products/

Section III. Annotated Public Comment Draft with Redlines

To provide a more detailed basis for the proposed revisions, the below text includes draft redlines along with annotations in line with the revised draft language. Other small clarifying changes have been made throughout the standard. Please see the full redlined standard here.

The red text shows proposed additions. Any text ~~with strikethrough lines~~ are proposed deletions.

Terminology Changes throughout the Standard

Green Seal proposes making changes to terminology throughout the Standard to use terms that align with the industry. These changes include:

- Using “recycled content” instead of “recovered material” when referring to material that has been recovered and reprocessed into a final product. When referring to material that has been recovered from waste streams and has not yet been reprocessed, the term “recovered material” will still be used.
- Using “post-consumer recycled content” instead of “post-consumer material.”
- Using “pre-consumer recycled content” instead of “pre-consumer material.”

Chlorine-free Bleaching Requirements for Alternative Fibers

Green Seal proposes adjusting the chlorine-free bleaching requirements for alternative fibers given the limited availability of Totally Chlorine Free (TCF) bleached alternative fiber pulp. Green Seal encourages manufacturers to continue to invest in their supply chains, including prioritizing improvements that reduce the environmental impacts of bleaching processes. Green Seal may consider revising the bleaching criteria for alternative fibers as more TCF bleached pulp becomes available.

2.1.3 Chlorine Free. Products made from *recycled content* ~~recovered fibers~~ shall be *Processed Chlorine Free (PCF)*. Products made from bamboo or agricultural residue shall be *Totally Chlorine Free (TCF)* or *Elemental Chlorine Free (ECF)*.

Additionally, chlorine or chlorine derivatives (e.g., elemental chlorine, chlorine dioxide, sodium hypochlorite, sodium chlorite) shall not be used during the following steps of the papermaking process: re-pulping, screening, deinking, and washing.[1]

Exemption: Chlorine and chlorine derivatives can be used during the re-pulping process if necessary to break down recovered material with wet-strength resins.

[1] There are no restrictions on the use of chlorine or its derivatives in the cleaning of production equipment.

2.1.4 Colorants in Product. The product shall not contain any *colorants* as *functional papermaking additives*; an exception shall be made for products that would not contain *colorants* but for ~~from~~ the addition of *recycled content* ~~*recovered materials.*~~

Per- and Polyfluoroalkyl Substances Prohibition

As part of Green Seal's ongoing work to address PFAS as a group of hazardous chemicals across Green Seal product categories, Green Seal proposes to prohibit the intentional addition of PFAS as a functional papermaking additive.

2.1.7 Per- and Polyfluoroalkyl Substances (PFAS). The product shall not contain any *functional papermaking additives* or *contaminants* that are *Per- and Polyfluoroalkyl Substances (PFAS).*

2.1.8~~7~~ Additional Prohibited Substances. The product shall not contain the following substances as *functional papermaking additives* or *contaminants*:
- *Fragrances*
- The heavy metals lead, chromium, or selenium both in the elemental form or compound

The *papermaking process* shall not use the following substances:
- Chlorophenolic *biocides*
- *Ozone-depleting compounds*

Adjustment to the Fiber Requirements

Green Seal proposes the following changes to the fiber requirements:

- Adjusting the post-consumer recycled content requirements to align with the Environmental Protection Agency (EPA) Comprehensive Procurement Guidelines. These adjustments promote harmonization and acknowledge supply challenges for PCR.
- Adding a pathway to the standard for sustainably sourced bamboo products to expand certification pathways while still providing clear environmental benefits.
- Creating a designation for products that meet the 100% recycled content and PCR requirements. This designation will help purchasers easily identify certified products made from recycled content.
- Requiring fiber analysis testing (TAPPI T 401 om-20 Fiber analysis of paper and paperboard) for alternative fibers (bamboo and agricultural residue) to ensure the integrity of these supply chains.

3.0 Responsible Sourcing

3.1 Fiber Requirements. ~~The fiber source shall meet one of the following:~~ The product shall comply with either Section 3.1.1 or Section 3.1.2.
~~a) The product shall be made from 100% recovered material, subject to the applicable requirement in section 3.2;~~
~~b) The product shall be made from 100% agricultural residue;~~

~~c) The product shall be made from any combination of recovered material and agricultural residue, provided that the recovered material is 100% post-consumer material, or the product meets the applicable requirement in section 3.2 herein.~~

3.1.1 100% Recycled Content. The product shall be made from 100% *recycled content*, subject to the applicable requirements in section 3.2.

For *recycled content* ~~*recovered material*~~ produced by *integrated mills* where *whitewater* and/or *wastewater* recovery may cause contamination of the incoming *recovered material furnish* (stock), reclaimed mixed fibers containing *virgin material* may be acceptable as long as it can be shown, through mass balance calculations, that the amount of *virgin fiber* in the reclaimed mixed fibers is less than 0.5% of the incoming *recovered material furnish* (stock).

Products that meet 3.1.1 are eligible for the 100% Recycled Content designation as outlined in Green Seal's Trademark Use Guidelines.[4]

[4] www.greenseal.org/trademark-use-guidelines

3.1.2 Alternative Fibers. The fiber source shall meet one of the following:
a) The product shall be made from 100% bamboo.
b) The product shall be made from 100% *agricultural residue*.
c) The product shall be made from any combination of *recycled content*, bamboo, and/or *agricultural residue*.

When using *agricultural residue*, the manufacturer shall document the original source of the material and provide fiber analysis testing (Technical Association of the Pulp and Paper Industry [TAPPI] T 401 om-20 Fiber analysis of paper and paperboard).~~, and t~~The *agricultural residue* shall originate from a crop certified to the Rainforest Alliance Sustainable Agriculture Standard, Roundtable for Sustainable Biomaterials (RSB) Standard for Advanced Products, or other approved *third-party certification program*.

When using bamboo, the manufacturer shall document the original source of the material and provide fiber analysis testing (TAPPI T 401 om-20 Fiber analysis of paper and paperboard). The bamboo shall originate from a source certified by the Forest Stewardship Council (FSC 100% Bamboo), Roundtable for Sustainable Biomaterials (RSB) Standard for Advanced Products, or other approved *third-party certification program*.

3.2 Post-Consumer Recycled Content ~~Material~~ Requirements. Products made from 100% *recycled content* ~~*recovered material*~~ shall meet the following requirements:

Product Type	**Post-Consumer Recycled Content Material Requirement (% in product)**
Paper Towels~~,~~ and *General-Purpose Wipers~~, and Napkins~~*	40% ~~50%~~
Paper Napkins	30%
Bathroom Tissue	20% ~~25%~~
Facial Tissue	10% ~~15%~~
Toilet Seat Covers	25%

Placemats/Tray Liners	50% ~~40%~~
Table Coverings	40%

3.3 Post-Consumer Consumer Recycled Content ~~Material~~ Calculations. The percentage of *post-consumer recycled content* ~~*material*~~ shall be calculated and certified based on the fiber weight of the paper. The calculation of *recycled content* based on fiber weight shall be performed using the following formula for *post-consumer recycled content* ~~*material*~~:

$$\frac{\textit{Post-consumer Recycled Content } \sout{\textit{Material}} \times \text{Yield}_{PC}}{\textit{Total Fiber } \sout{\textit{Recovered Material or Agricultural Residue}} \times \text{Yield}_{\sout{RT}}}$$

Yield will depend on the product manufactured, the raw material, the level of contaminants, and the cleaning and deinking technology employed. The percentage yield shall be calculated by dividing the total material output by the total material input.[5] The percentage of *recycled content,* ~~*recovered material*~~ bamboo, or *agricultural residue* and *post-consumer recycled content* ~~*material*~~ shall be calculated based on a weighted average of the materials used for a period of time not to exceed the previous three months.

[5] If a particular manufacturer's operating procedures do not provide for accurate yield measurements, the following shall be used as default values:

Default Recovered Material or Agricultural Residue Total fiber yield ($\text{Yield}_{\sout{RT}}$): 75%
Default Post-Consumer Material yield (Yield_{PC}): 75%

Adjustments to the Low-Impact Manufacturing Requirements

The manufacturing phase of sanitary paper products contributes to greenhouse gas emissions and is energy and water intensive. Currently, manufacturers must demonstrate they comply with Good Manufacturing Practices (GMP) to ensure products are made safely, efficiently, and consistently. While these requirements are part of Green Seal's current certification process, we propose codifying these requirements in the standard language to increase clarity and transparency on what is required to be certified. Additionally, Green Seal proposes adding Environmental Management System (EMS) requirements to reduce the impacts of the manufacturing stage of certified products. The EMS criteria will build on existing standard criteria by requiring manufacturers to report and comply with energy and water use thresholds while also tracking and reducing greenhouse gas emissions.

4.2 Good Manufacturing Practices. The manufacturing facility shall exhibit good manufacturing practices as verified through an on-site audit or through a valid certification such as ISO 9001.[6]

[6] Additional examples of valid certifications can be found at [link forthcoming].

4.3 Environmental Management System. The manufacturing facility shall have in place or develop an effective Environmental Management System (EMS) to report on and meet the requirements for the endpoints in Section 4.3.1 (Water and Energy Use) and 4.3.2 (Greenhouse Gas

Emissions). The manufacturing facility shall provide either documentation demonstrating the system contains the following elements or a valid certification such as ISO 14001:
• An environmental policy with clear scope, organizational context, objectives, and actions to achieve those objectives. Considerations relevant to understanding the context of the organization include environmental conditions related to climate, air quality, water quality, land use, existing contamination, natural resource availability, and biodiversity.
• Commitment to the EMS by top management in the organization.
• Policies and procedures to manage the EMS including:
    ▫ Measuring and evaluating activities against the environmental policy.
    ▫ Implementing and summarizing results of an annual EMS audit.
    ▫ Implementing corrective actions.
• A needs assessment of staff education to implement the EMS.
• Continued improvement of the organization's environmental performance.

For manufacturers that do not currently have an EMS in place, the manufacturer shall continue to demonstrate progress toward developing the EMS during formal monitoring events until the EMS is fully in place.

4.3.1 Manufacturing and Converting Requirements – Water and Energy Use.
Manufacturers shall meet the following freshwater and *energy use* criteria, for combined processes including pulping, re-pulping, deinking, papermaking, product converting, and waste treatment (on-site or offsite facilities).

If a manufacturer only does converting, then the energy and water use for the other processes (pulping, re-pulping, deinking, papermaking, and waste treatment) shall be supplied by the manufacturer of the *parent roll*.

If a manufacturer purchases market de-inked pulp (MDIP), then the supplier of the MDIP will be required to provide the energy and water use data associated with production of the MDIP. This supplier data regarding energy and water use in production of MDIP shall meet the criteria in this section separately and in addition to the data from the paper manufacturer itself.

The data shall represent either the total annual resource used divided by the total annual production of paper,[5] or the total annual resource used to produce all grades of certified paper divided by the total annual production of all grades of certified paper.[6] This implies that estimation and allocation methods are acceptable.

Fresh Water Use (gallons /ton of final product) [(a)]	**Total Energy Use (millions BTUs/ ton of final product)** [(b)]
19,250	17.0

(a) gallons/T = 0.00417 m3/MT

(b) millions of British Thermal Units (BTUs)/T = 1.16 Gigajoules/MT = 323.2 kilowatt-hour/MT

4.3.2 Greenhouse Gas Emissions.

The manufacturing facility shall report on and show improvement against its greenhouse gas emissions as part of the requirements for its EMS in Section 4.3. The manufacturer shall report during formal monitoring events using an acceptable reporting scheme such as the Greenhouse Gas (GHG) Protocol, the Global Reporting Initiative (GRI), Carbon Disclosure Project (CDP), ISO 14064-1:2018, the EPA Greenhouse Gas Reporting Program (GHGRP) or another approved by Green Seal.

Changes to Packaging Requirements

Green Seal proposes changing the packaging requirements to align with terminology used in the industry (e.g., "recycled content" instead of "recovered material"), as noted above. No other changes are proposed to this section.

5.0 Sustainable Packaging

5.1 Packaging Materials

5.1.1 Primary and Secondary. *Primary* and ~~*S*~~*secondary packaging* shall meet the following requirements based on the packaging material type:
• Packaging made from paper or paperboard shall be *recyclable* and made from 100% *recycled content* ~~*recovered material*~~.
• Packaging made from containerboard (corrugated cardboard) shall be *recyclable* and made from at least 30% *recycled content* ~~*recovered material*~~.
• Packaging made from plastic shall be *recyclable*, or a *source-reduced package*, or shall contain 25% *recycled content* ~~*recovered material*~~ (*pre- or post-consumer recycled content* ~~*material*~~). Where a product's packaging is below these levels, the manufacturer shall demonstrate that efforts have been made to use the maximum available *pre- or post-consumer recycled content* ~~*material*~~ in packaging. An exception shall be made for packaging with an effective *take-back program*.

5.1.2 Colorants ~~i~~in Packaging. *Primary* and *secondary packaging* may be printed using *colorants* provided that these *colorants* contain a sum concentration of less than 100 ppm by weight of lead, mercury, cadmium, and hexavalent chromium.

5.2 Packaging Label

5.2.1 Resin Identification Code. If plastic, the packaging the packaging shall be marked with the appropriate Resin Identification Code.

5.3 Restricted Substances

5.3.1 Heavy Metal Restrictions. The heavy metals lead, mercury, cadmium, and hexavalent chromium shall not be *intentionally introduced* in *primary* and *secondary packaging*. Further, the sum of the concentration levels of these metals shall not exceed 100 ppm by weight (0.01%); an exception is allowed for packaging that would not exceed this maximum level but for the addition of *recycled content* ~~*recovered materials*~~.

5.3.2 Other Restrictions. Phthalates, bisphenol A, and chlorinated packaging material are prohibited from being intentionally introduced to plastic primary or secondary packaging; an exception is allowed for packaging that would not have added phthalates, bisphenol A, or chlorinated packaging material but for the addition of ~~*post-consumer*~~ *recycled content* ~~*material*~~.

Changes to the Performance Testing Requirements

Green Seal proposes removing the basis weight requirements and updating the referenced test methods for tensile strength and stretch. Additionally, we propose a few changes to acceptable thresholds for tensile strength and stretch based on industry feedback on appropriate performance for these product types. For clarity, the requirements for stretch and water absorbency have been separated into two criteria.

~~**6.1.1 Basis Weight.** Basis weight (grammage) shall be measured according to Technical Association of the Pulp and Paper Industry (TAPPI) T 410 or International Organization for Standardization (ISO) 536. It shall also meet the following requirements when measured as grams per square meter (g/m2, SI Units) or pounds/ream (lbs/ream, English units):~~

~~Product~~	~~Basis Weight (lbs/ream[(b)])~~	~~Grammage [(a)] (g/m^2)~~
~~*Institutional paper towels* – hard wound~~	~~15-35~~	~~24.4-56.9~~
~~*Institutional paper towels* – center pull~~	~~11-28~~	~~17.9-45.6~~
~~*Institutional paper towels* – folded~~	~~15-35~~	~~24.4-56.9~~
~~*Institutional paper towels* – kitchen roll~~	~~11-30~~	~~17.9-48.8~~
~~*General purpose wipers*~~	~~15-35~~	~~24.4-56.9~~
~~*Retail paper towels* – folded~~	~~15-35~~	~~24.4-56.9~~
~~*Retail paper towels* – kitchen roll~~	~~11-30~~	~~17.9-48.8~~
~~*Paper napkins*~~	~~9-28.5~~	~~14.6-46.4~~
~~*Bathroom tissue*~~	~~7.5-22~~	~~12.2-35.8~~
~~*Facial tissue*~~	~~7.5-19~~	~~12.2-30.9~~
~~*Toilet seat covers*~~	~~7.5-10.5~~	~~12.2-17.1~~
~~*Placemats*/Tray Liners~~	~~26-40~~	~~38.5-59.2~~
~~*Table coverings*~~	~~15-22~~	~~22.2-32.6~~

~~(a) See TAPPI T 1210 Table 1, Section 1.1 for conversion factors (Basis weight [pounds/ream]*1.6275 = Grammage [grams per square meter]).~~
~~(b) Based on a 24 inch x 36 inch -500 sheet ream, or 3000 sq. ft.~~

6.1.12 Tensile Strength (Dry and Wet). Product characteristics shall be measured for tensile strength in the machine direction (MD) and cross direction (CD) using the methods described in either ~~s~~Section 6.1.1.1 ~~6.1.2.1~~ or ~~s~~Section 6.1.1.2 ~~6.1.2.2~~.

6.1.12.1 Tensile strength using TAPPI T 581 ~~494/456~~. Product characteristics shall meet the following requirements when tested according to TAPPI T 581 om-22 Dry Tensile Properties of Paper Towel and Tissue Products (using constant rate of elongation apparatus) ~~494~~ or ISO 12625-4:2022 (Tissue paper and tissue products – Part 4: Determination of tensile strength, stretch at

maximum force, and tensile energy absorption) ~~1924/3 (~~ for dry tensile strength~~)~~ and TAPPI T 456 om-22 Tensile breaking strength of water-saturated paper and paperboard or ISO 12625-5:2024 (Tissue Paper and Tissue Products – Part 5: Determination of Wet Tensile Strength) ~~(~~for wet tensile strength~~)~~, as measured in gram force/inch (gf/in, English units):

Product	**Dry Tensile Strength**[(a)]		**Wet Tensile Strength**[(b)]	
	MD (gf/in)	**CD** (gf/in)	**MD** (gf/in)	**CD** (gf/in)
Institutional paper towels – hard wound	1000~~1700~~ -3100	600-2000	250-850	100-700
Institutional paper towels – center pull	400-1500	100-800	100-500	50-200
Institutional paper towels – folded	800-2700	200-1300	230-600	90-400
Institutional paper towels – kitchen roll	400-1300	100-650	100-350	50-200
General purpose wipers	800-2700	200-1300	230-600	90-400
Retail paper towels – folded	800-2700	200-1300	230-600	90-400
Retail paper towels – kitchen roll	400-1200	100-640	100-300	50-170
Paper napkins	350-1500 ~~400-1100~~	125-600 ~~230-570~~	--	--
Bathroom tissue	140-900	50-450	--	--
Facial tissue	250-750	80-250	15-80	8-40
Toilet seat covers	800-2250	200-1100	--	--
Placemats/Tray Liners	--	--	--	--
Table coverings	--	--	--	--

(a) See TAPPI 1210, Table 1, Section 2.1 for conversion factors

(b) Wet tensile strength data needs to be provided only in one direction (MD or CD)
(1 gf/in = 0.3886 newton/meter (N/m); 1 oz/in = 10.945 N/m)

-- = no requirement

6.1.1~~2~~.2 Tensile strength using TAPPI T581/456 ~~T 576~~. Product characteristics shall meet the following requirements when tested according to TAPPI T 581 om-22 Dry Tensile Properties of Paper Towel and Tissue Products (using constant rate of elongation apparatus) ~~T 576 (~~for dry ~~and wet~~ tensile strength~~)~~ and TAPPI T 456 om-03 Tensile Breaking Strength of Water-Saturated Paper and Paperboard (“wet tensile strength”) for wet tensile strength, as measured in gf/3in (English units):

Product	**Dry Tensile Strength**[(a)]		**Wet Tensile Strength**[(b)]	
	MD (gf/3in)	**CD** (gf/3in)	**MD** (gf/3in)	**CD** (gf/3in)
Institutional paper towels – hard wound	3000~~5100~~ -9300	1800-6000	750-2250	300-2100
Institutional paper towels – center pull	1200-4500	300-2400	300-1500	150-600
Institutional paper towels – folded	2400-8100	600-3900	690-1800	270-1200
Institutional paper towels – kitchen roll	1200-3900	300-1950	300-1050	150-600
General purpose wipers	2400-8100	600-3900	690-1800	270-1200

Retail paper towels – folded	2400-8100	600-3900	690-1800	270-1200
Retail paper towels – kitchen roll	1200-3600	300-1920	300-900	150-510
Paper napkins	1050-4500 ~~1200-3300~~	375-1800 ~~690-1710~~	--	--
Bathroom tissue	420-2700	150-1350	--	--
Facial tissue	750-2250	240-750	45-240	24-120
Toilet seat covers	2400-6750	600-3300	--	--
Placemats/Tray Liners	--	--	--	--
Table coverings	--	--	--	--

(a) See TAPPI 1210, Table 1, Section 2.1 for conversion factors

(b) Wet tensile strength data needs to be provided only in one direction (MD or CD)
(1 gf/3in = 0.1295 ~~0.3886~~ newton/meter (N/m); 1 oz/in = 10.945 N/m)

-- = no requirement

6.1.3 Stretch and ~~Water Absorbency.~~ Product characteristics shall meet the following requirements when tested according to TAPPI T 581 om-22 Dry Tensile Properties of Paper Towels and Tissue Products (using constant rate of elongation apparatus) ~~494~~ or ISO 12625-4:2022 Tissue Paper and Tissue Products – Part 4: Determination of Tensile Strength, Stretch at Maximum Force, and Tensile Energy Absorption ~~1924/3, or TAPPI T 576~~ for stretch~~, and TAPPI T 432 for water absorbency,~~ as measured in % stretch ~~or seconds of water absorbency~~:

Product	**Stretch**	~~**Water Absorbency**~~
	(%)	~~(seconds)~~
Paper towels – institutional	2-22	~~0-160~~
Paper towels – retail	2-22	~~0-160~~
General-purpose wipers	2-22	~~0-160~~
Paper napkins	2-34 ~~22~~	~~0-180~~
Bathroom tissue	2-24	~~—~~
Facial tissue	2-24	~~—~~
Toilet seat covers	--	~~—~~
	1-10	
Placemats/Tray liners	1-10	~~—~~
Table Coverings	--	~~—~~

6.1.4 Water Absorbency. Product characteristics shall meet the following requirements when tested according to TAPPI T 432 cm-21 Water Absorbency of Bibulous Papers for water absorbency, as measured seconds of water absorbency:

Product	Water Absorbency (seconds)
Paper towels – institutional	0-160
Paper towels – retail	0-160
General-purpose wipers	0-160
Paper napkins	0-180
Bathroom tissue	--
Facial tissue	--
Toilet seat covers	--
Placemats/Tray liners	--
Table Coverings	--

Changes to Definitions

Green Seal proposes the following changes to the definitions in the standard to incorporate language relevant to bamboo fibers and to ensure the standard uses terminology that aligns with the industry.

Annex A – Definitions (Normative)

Elemental Chlorine Free (ECF). Bleaching process for virgin-content papers, including those made from agricultural residue or bamboo, that exclusively substitutes chlorine dioxide for elemental chlorine and hypochlorite.[9]

[9] 40 CFR part 403.3: https://www.ecfr.gov/current/title-40/chapter-I/subchapter-N/part-430/subject-group-ECFRa125908ec48b03f/section-430.01

Energy Use. The total energy used to manufacture *sanitary paper products*, including the net energy consumption during re-pulping of recovered material, ~~or~~ bamboo, or agricultural residue pulping, throughout the paper making process, during waste treatment, and during converting and/or packaging. Net energy consumption is considered energy purchased and generated less sales. It does not include transportation.

Fresh Water Use. The total amount of steam, process, and cooling water used in the manufacture of *sanitary paper products*, including water used during re-pulping of *recovered material* or pulping of bamboo or *agricultural residue*, throughout the ~~paper~~ papermaking process; and during converting (if applicable). Fresh water does not include *whitewater* or other recycled water streams.

Functional Papermaking Additives. *Functional papermaking additives* are those that are added to the paper machine *furnish* primarily for retention within or on the product, such as fillers, sizing agents, retention aids, wet- and dry-strength resins, *colorants*/dyes, and *optical brighteners*. Other materials added to the process through the water to facilitate the papermaking process, during drying, or in wastewater treatment, are not considered functional ~~paper~~ papermaking additives, including, but not limited to, cooling tower or boiler chemicals, paper machine cleaners, surfactants, detergents, defoamers, dispersants, foaming agents, collectors, dryer coating or release aids, and flocculants.

Furnish. The mixture of *recovered material* fiber, bamboo, or *agricultural residue* fiber and other chemicals that is blended in a water suspension, or slurry, from which paper products are made. Also referred to as stock.

Per- and Polyfluoroalkyl Substances. A class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom.

Post-Consumer Recycled Content ~~Material~~. Material that would otherwise be disposed of as *solid waste*, having completed its intended end-use by the consumer. *Post-consumer material* does not include materials or *by-products* generated from, and commonly reused within, an original manufacturing and fabrication process.

Pre-Consumer Recycled Content ~~Material~~. Material diverted from a waste stream during the manufacturing process, excluding material such as rework, regrind, or scrap generated in a process and capable of being reused within the same process that generated it.

Processed Chlorine Free (PCF). Paper products made from *recovered materials* that may have been, in their original manufacturing process, bleached using chlorine or chlorine-derivatives (e.g., elemental chlorine, chlorine dioxide, sodium hypochlorite, sodium chlorite), but were not re-bleached with chlorine or chlorine-derivatives. ~~Any virgin fiber[8] or agricultural residue incorporated into the final product is *Totally Chlorine Free*.~~

~~[8] This definition is consistent with common use in industry. GS-1 only covers products that are made from waste materials (i.e., recovered material and agricultural residue). Virgin fiber is not an acceptable raw material for products certified to GS-1.~~

Product Performance. Measurable outcome(s) resulting from a product's functional characteristics that satisfy health, safety, or user needs.

Recovered Material. Either material recovered from or otherwise diverted from the solid waste stream, that is generated after the completion of the paper manufacturing process; or fiber and broke recovery that contains 100% recovered material and is integral to the manufacturing process from which it was generated.

~~Recovered material may include:~~
~~• *Pre-consumer materials* such as finishing waste generated after completion of the • *papermaking process* (i.e., during converting), such as envelope cuttings; bindery trimmings; printing waste; cuttings and other converting waste (*finishing broke*); butt rolls and mill wrappers; obsolete inventories; and rejected unused stock.~~

~~• *Post-consumer materials* such as paper, paperboard, and fibrous materials from *retail* stores, office buildings, homes, etc., after they have completed their intended end-use.~~
~~• Fibers recovered from *whitewater* or *wastewater*, or *mill broke* (wet or dry) generated from the manufacturing process used only to make the certified product (i.e., *mill broke* containing 100% *recovered material*).~~

~~*Recovered material* does not include:~~
~~• Fibers recovered from *whitewater* or *wastewater*, or *mill broke* (wet or dry) generated from the manufacturing process used to make non-certified products containing virgin material (i.e., *mill broke* containing any virgin material), regardless of whether such materials are used by the same or another company.~~
~~• Forest residue such as fibrous *by-products* of harvesting, extractive, or woodcutting processes.~~

Recycled Content.[10] Material that has been reprocessed from recovered material by means of a manufacturing process and made into a final product or into a component for incorporation into a product.
Recycled content may include:
• *Pre-consumer recycled content* such as finishing waste generated after completion of the *papermaking process* (i.e., during converting), such as envelope cuttings, bindery trimmings, printing waste, cuttings and other converting waste (*finishing broke*), butt rolls and mill wrappers, obsolete inventories, and rejected unused stock.
• *Post-consumer recycled content* such as paper, paperboard, and fibrous materials from *retail* stores, office buildings, homes, etc., after they have completed their intended end-use.
• Fibers recovered from *whitewater* or *wastewater*, or *mill broke* (wet or dry) generated from the manufacturing process used only to make the certified product (i.e., *mill broke* containing 100% *recovered material*).

Recycled content does not include:
• Fibers recovered from *whitewater* or *wastewater*, or *mill broke* (wet or dry) generated from the manufacturing process used to make noncertified products containing virgin material (i.e., *mill broke* containing any virgin material), regardless of whether such materials are used by the same or another company.
• Forest residue such as fibrous *by-products* of harvesting, extractive, or woodcutting processes.

[10] Referred to in ISO 14021 as “recycled material.” For the purposes of this standard, “recycled content” is used as it is the industry-accepted term.

Virgin Fiber/Material. Primary ~~F~~fiber/material (i.e., material that is not ~~of recovered or post-consumer origin~~ *recycled content or agricultural residue)* originating from forests or plantations.

Section IV. Research Record

The following section summarizes the market and technical research on sanitary paper products including the lifecycle impacts of different fiber types and a market overview.

Product Category Overview

Product Category Terms

Sanitary paper products are primarily single-use items used to absorb liquids. Sanitary paper is part of the global paper and paperboard industry. This industry includes the following products:

- Graphic paper, such as newsprint, uncoated mechanical paper, uncoated woodfree paper, and coated paper
- Packaging material, such as case materials, folding boxboard, wrapping paper, and other papers for paperboard
- Household and sanitary paper, which includes various tissue and hygiene products, such as facial tissues, toilet paper, napkins, and paper towels
- Other paper and paperboard

Paper and paperboard products are typically made from wood pulp, which can include both virgin and recycled sources. While overall wood pulp and paper demand has been declining for over a decade, household and sanitary paper products are the fastest-growing sector in the paper industry.[17] These products may also be made from alternative fibers including wheat straw, bagasse, and bamboo. This market has seen growth in alternative fibers, particularly bamboo sanitary paper products. The bamboo sanitary paper market is projected to experience significant growth at a compound annual growth rate (CAGR) of 16.45% by 2030.[18]

Current Product Market

Household and sanitary paper are used in at-home and away-from-home settings (i.e., residential and commercial settings). At-home and away-from-home are considered two separate markets with different needs and preferred product characteristics.[19]

Table 1: Tissue Market Overview – At-Home and Away-From-Home Markets[19]

	At-Home Market (AH)	Away-From-Home Market (AFH)
Primary Customer and Use	Purchased by consumers from retailers and used in the home.	Purchased by commercial businesses or institutions and supplied for public use in

[17] The Issue with Tissue 2.0: How the Tree-To-Toilet Pipeline Fuels Our Climate Crisis. https://www.nrdc.org/sites/default/files/issue-with-tissue-2-report.pdf
[18] Bamboo Toilet Paper Market – Global Trend and Outlook to 2031. https://www.htfmarketintelligence.com/report/global-bamboo-toilet-paper-market
[19] Dynamic Fiber Flows Model, Case Study on Tissue Products. *https://www.afandpa.org/statistics-resources/dynamic-fiber-flows-model*

		places like schools, hospitals, restaurants, hotels, offices, and other public spaces.
Key Product Characteristics	Generally, prioritize high quality, softness, absorbency, ease of use, efficiency, and brightness.	Often prioritize value. Packed and purchased in bulk and used in high volume dispensers that meet the economic and replenishment needs of institutional buyers.
Fiber Concentration	Primarily virgin fiber.	Primarily recycled fiber.

In 2020, world household and sanitary paper production was 37,019,000 tonnes.[20] North American production of sanitary and household papers rose to 8 million tonnes,[21] while North American apparent consumption[22] rose over 4 percent to 8.3 million tonnes or 29.5 pounds per person.[21,23]

Product Life Cycle Impacts

Green Seal's aim is to determine the most significant life cycle impacts across the supply chain and identify products' leadership attributes that are verifiable via document disclosure, traceability reviews, and manufacturing plant on-site reviews. To identify the leadership attributes of a product category, Green Seal conducts a content review of company websites, industry association reports, and peer-reviewed journal articles as well as utilizing the expertise of our volunteer Working Group committee of market and technical experts. The summaries below describe the supply chains and life cycles of household and sanitary paper products with and without recycled content and alternative fibers. These summaries provide part of the landscape analysis that Green Seal developed as a foundation for standard criteria development.

Supply Chain Summary

At a high level, the household and sanitary paper supply chain includes the following components:

- **Wood Harvesting:** Harvesting of virgin forest products through logging.
- **Pulpwood Production:** Harvested inputs are processed into pulpwood prior to primary processing.
- **Primary Processing:** Chemical or mechanical processing takes place to produce pulp.
- **Secondary Processing / Manufacturing:** Pulp is further processed and manufactured into paper and paperboard products, which include household and sanitary paper products.
- **Distribution:** Products are shipped to distributors and retailers.
- **Use:** Household and sanitary paper products are used and immediately disposed of.

[20]Forest Products 2020. https://www.fao.org/documents/card/en/c/cc3475m
[21] Forest Products Annual Market Review 2020-2021. https://unece.org/forests/publications/forest-products-annual-market-review-2020-2021
[22] Apparent consumption is defined as the sum, in tonnage, of production and imports, minus exports.
[23] World Population Review – North America. https://worldpopulationreview.com/continents/north-america#:~:text=North%20America%20is%20the%20third,%25%20of%20World%20Population

- **Disposal and End-of-Life Stage:** Products are typically flushed or landfilled (and in some cases, composted).

Within North America, the United States is a major driver of pulp and household and sanitary paper. The United States accounted for 7,513,000 of the 8,260,000 tonnes of household and sanitary paper consumed in North America in 2020.[20]

In addition, a major portion of Canada's pulp and paper exports are driven by demand from the United States. U.S. pulp and paper demand accounted for 67 percent of all Canada's pulp and paper exports in 2024.[24] Further, according to NRDC, "roughly one-third—and for some products as much as 75 percent—of the pulp used to make tissue products in the United States is Northern Bleached Softwood Kraft (NBSK) pulp from Canada's boreal forest region."[17] That same year, the United States imported a total of 5,665,000 tonnes of pulp and paper. Other sources of pulp and paper imports to the United States include Brazil and Sweden.[25]

Given these consumption and import/export dynamics, the health and environmental consequences associated with each life cycle stage outlined in the Life Cycle Impacts section will assume wood harvesting is taking place in either the United States or the Boreal Forest region of Canada.

Recycling Process. Both household and sanitary paper products can be made with recycled content. Recycled content can be recovered from either post-industrial or post-consumer sources. Recovery and recycling often occur via an "open loop" system. In an open loop system, the primary recycled sources are recovered from municipal collection bins, retail front-of-house collection bins, retail back-of-house collection bins, and distribution centers. Recycled content requires deinking and primary processing to become an input into pulp production. Once repulped, recycled content follows a similar supply chain as described above for virgin fiber. In today's North American market, household and sanitary paper products generally contain 0 to 100 percent recycled content, with recycled content products much more common in the away-from-home market than the at-home market. Per our market analysis, roughly 70 percent of the at-home market contains 0 percent recycled content.

Life Cycle Impacts

The summaries below of the life cycle stages of household and sanitary paper products use the framework of the ISO 14040 Standard: raw material acquisition (i.e., harvesting), manufacturing, distribution and transportation, use, disposal, and end of life.

The impacts of household and sanitary paper products are wide ranging and include large effects on energy use and emissions, air and water quality degradation, and generation of greenhouse gas emissions. Mainly due to large amounts of raw material, relatively low yield from logging to paper output, and energy inputs and associated greenhouse gas emissions. Production of household and sanitary paper products includes harvesting and logging lumber from forests, transporting that

[24] Annual Exports by Province. https://www2.gov.bc.ca/assets/gov/data/statistics/business-industry-trade/trade/exp_annual_exp_prov.pdf
[25] Observation of Economic Complexity (OCE): Wood and Pulp in United States.https://oec.world/en/profile/bilateral-product/wood-pulp-paper-scrap/reporter/usa

material, producing wood pulp, manufacturing paper, and then distributing it for sale. The major health and environmental impacts of each stage in this process are summarized in Table 2.

Table 2. Main health and environmental impacts from life cycle of household and sanitary paper products

Life Cycle Stage	Emissions	Energy Use	Water Usage, Quality	Chemical Exposure	Waste
Raw material acquisition	x	X	x	x	x
Manufacturing	x	x	x	x	x
Transportation	x	x			
Use					x
Disposal, end of life	x				x

Raw Material Acquisition

Wood Harvesting

As it pertains to wood inputs, industrial roundwood serves as the primary wood product that feeds the solid wood product and the pulp and paper sector.[26] The United States has historically been the largest worldwide producer of industrial roundwood annually, and Canada is consistently among the top five global producers. Today, the United States remains the world's leading producer of industrial roundwood, and Canada is the fifth largest producer, as shown in Table 3.

Table 3: Industrial Roundwood Removals, Worldwide and Top 5 Countries

Industrial Roundwood Removals,[20] 1000m^3					
Location	**2016**	**2017**	**2018**	**2019**	**2020**
World (total)	1,922,732	1,951,903	2,068,275	2,019,102	1,983,688
United States	374,476	376,415	392,510	387,702	369,175
Russian Federation	198,194	197,612	219,569	203,194	201,891
China	162,965	161,711	180,237	180,237	180,237
Brazil	145,102	155,955	158,056	142,989	142,989
Canada	154,694	155,183	155,629	139,817	130,430

The vast majority of roundwood is kept in the country, and feeds as input to various end products, including those in the pulp and paper industry.

In 2005, the South was the largest lumber-producing region in the United States at 24 billion board feet of lumber, followed by the West at 18.3 billion board feet. [27] This level of production peaked in

[26] The Global Position of the US Forest Products Industry. https://www.srs.fs.usda.gov/pubs/gtr/gtr_srs204.pdf
[27] U.S. Timber Production, Trade, Consumption, and Price Statistics, 1965–2017. https://www.fpl.fs.usda.gov/documnts/fplrp/fpl_rp701.pdf

2005 then dropped significantly and has slowly approached parity in volume production around 2017 (see Figure 1).[27]

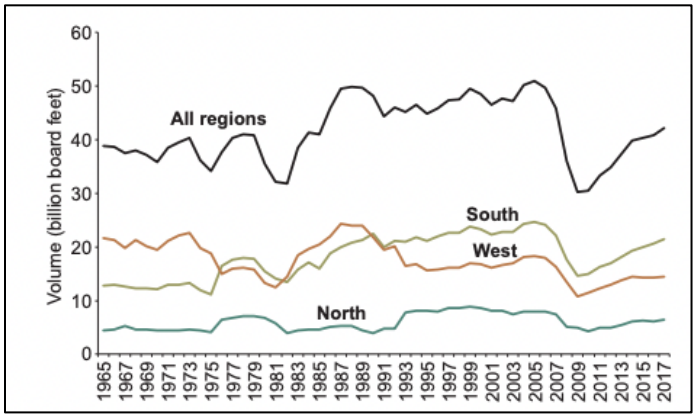

Figure 1: U.S. Lumber Production by Region, 1965-2017, from U.S. Timber Production, Trade, Consumption, and Price Statistics 1965-2017

In Canada, wood is harvested from the Boreal forests, which stretches from Newfoundland and Labrador on the Atlantic Coast to northeastern British Columbia and the Yukon Territory. It is the largest intact forest left in the world.[28] About 94% of Canada's forests are on publicly owned land, which enables the government to regulate harvesting practices and apply land-use planning through legislation and other policies.[29] In addition, the boreal forest in Canada has been home to Indigenous Peoples for thousands of years, and more than 600 of these communities continue to rely on the forest's wildlife and plants for food, clothing, medicine, tools, and shelter.[28]

Wood Processing and Chip Cutting

The wood must be processed before wood pulp can be produced. [30] Once harvested, wood is obtained as intact logs or as residuals from other processes (e.g., sawmill chips). The wood is stored near the harvest site as piles of logs. Storage at this stage can often last one year or more, resulting in a fair amount of lumber loss. Long-term storage of logs can lead to wood rotting and difficulty debarking. Sawmill chips are often stored in open chip piles. These piles lose mass and moisture quickly during storage — about 1% per month — and can create spontaneous ignition.

Tree bark contains several compounds that disturb pulping and bleaching, so it must be removed through the debarking process before pulping.[30] To be prepared for chemical pulping methods, the debarked wood must be cut into chips. Wood is chipped using a disk chipper prior to pulping, so that pulping chemicals are evenly and efficiently delivered once the chemical process begins. However, cutting wood into chips also cuts the fibers. Chipping causes more wood losses through formation of

[28] Canada's Boreal Forest: Why It's So Important. https://www.nrdc.org/stories/canadas-boreal-forest-why-its-important
[29] Boreal forest. https://natural-resources.canada.ca/our-natural-resources/forests/sustainable-forest-management/boreal-forest/13071
[30] Pulp. In Ullmann's Encyclopedia of Industrial Chemistry. https://doi.org/10.1002/14356007.a18_545.pub4

dust, shavings, and sticks. In addition, cracks are created in the cell layers, which results in weaker fibers and lower yield.

Industrial logging operations, including processing and chip cutting, drive the following impacts:

Forest Degradation and Fragmentation: Forest degradation results when there are changes within the forests that negatively affect the structure or function of the stand or site and thereby lower the capacity to supply products and/or ecosystem services. Forest fragmentation results when a large forest is divided into many smaller patches causing habitat fragmentation and other ecosystem services impacts. Intensive harvest to produce wood products can directly lead to fragmentation, which threatens forest animals, and degradation. As natural forests are fragmented and degraded, biodiversity loss accelerates and forest health declines, which can ultimately lead to complete deforestation.

Habitat, Biodiversity, and Endangered Species Loss. This issue is particularly important in developed countries such as the United States and Canada when high-conservation value forests (e.g. the Canadian Boreal) are logged. The Canadian boreal forest provides refuge to a wide variety of wildlife, such as salmon, black bears, and snowshoe hares. [28] The boreal is also critical to North America's bird population, serving as the nesting grounds for more than three billion birds. Many boreal animals, such as the woodland caribou, are facing extinction due to habitat loss from industrial logging and other extractive industries.

Soil Damage and Erosion. According to the U.S. EPA, "in a forested watershed, logging has the effect of both compacting and loosening soils due to the construction and use of roads, use of heavy machinery, logs being dragged over the ground or otherwise transported to yarding areas, and vegetation being removed."[31] Soil erosion and impoverishment from forest clearing or poor logging and road-building practices can lead to incidents of major regional and national flooding and water contamination. Logging in boreal forests can "alter biogeochemical processes in soils by changing forest composition, plant uptake rates, soil conditions, moisture and temperature regimes, soil microbial activity, and water fluxes." [32]

Ecosystem Change. Converting diverse natural forests to monoculture tree farms can result in significant change in habitat, land cover, and ecosystem services. This negatively affects the local communities and Indigenous Peoples dependent on the forest, as well as the health of the forest, including loss of ecological and biological diversity, non-timber forest products, clean water, and soil for food production.[33]

Water Quality Degradation. Logging, road construction, tree planting, chemical applications — including fertilizers, herbicides and pesticides applied to tree plantations — and other harvesting activities drive erosion, sedimentation, temperature changes that disturb aquatic life, toxicity issues, and other negative impacts. According to the U.S. EPA, "research in Canada has demonstrated that

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[31] Chapter 2: Water Quality and Forestry Activities. https://www.epa.gov/sites/default/files/2015-10/documents/ch2.pdf
[32] Logging impacts on the biogeochemistry of boreal forest soils and nutrient export to aquatic systems. https://doi.org/10.1139/A08-006
[33] Statement: Monoculture Tree Plantations Are Not Forests. https://environmentalpaper.org/2022/09/statement-monoculture-tree-plantations-are-not-forests/

clear-cut harvesting can lead to increased mercury concentrations in runoff (McIlroy, 2001). Mercury is carried through the atmosphere from areas with sources such as coal combustion and incinerators and can be deposited in forested areas. When those forested areas are clear-cut harvested, the additional runoff generated after the trees are removed might lead to increased mercury concentrations in the runoff."[31]

Greenhouse Gas Emissions and Loss of Carbon Storage Capacity: Greenhouse gas emissions are generated from industrial logging activities. Industrial logging activities also disrupt the natural carbon cycle and, as a result, most of the carbon that would have been stored in the forest and soils is released into the atmosphere. In Canada, due to its colder temperatures, the boreal is slow-growing, and its dead vegetation and leaves are slow to decompose, building thick layers of organic material called peat that store carbon.[34] Logging these areas releases greater stores of carbon. Logging activities contribute to the following climate impacts:

- Harvesting vehicle emissions and transport constitute around 8.5% of paper production and consumption's climate impact (for household and sanitary paper products, around 2,225 units of CO_2 equivalent/metric tonnes of paper).[35]
- The direct and equivalent emissions from forest landscape impacts, including the release of carbon from trees (as CO_2) and forest ecosystems, in addition to the loss of sequestration due to harvest and the regrowth of trees post-harvest, constitutes around 11.7% of paper production and consumption's climate impact (for household and sanitary paper products, around 3,063 units of CO_2 equivalent/metric tonnes of paper).[35]

Climate impacts Net ecosystem productivity (NEP) — sequestration by young seedlings and brush minus emissions from decay and combustion of logging residuals — is negative for 3 to 15 years after clearcutting, meaning that these lands are not only carbon sequestration dead zones, but net emissions sources during this time period. [36]

Violation of Indigenous and Forest Dependent Peoples' Rights, Culture and Identity: In the Canadian boreal region, forest management and forest conversion in regions where the rights of Indigenous Peoples are not respected can result in displacement and loss of land use access and livelihoods. Conflicts with local communities can also arise over rights to timber extraction or distribution of revenues from timber sales. These factors can result in erosion of culture and identity.

Wood Pulp Production and Product Manufacturing Stage

The pulp production and papermaking process described below is extremely energy intensive and creates significant environmental impacts, including air and water pollution, and large energy and water consumption.

[34] A Tale of Two Forests: A Tour Through Canada's Boreal. https://www.nrdc.org/stories/tale-two-forests-tour-through-canadas-boreal
[35] The State of the Global Paper Industry. https://environmentalpaper.org/wp-content/uploads/2018/04/StateOfTheGlobalPaperIndustry2018_FullReport-Final-1.pdf
[36] Climate Impacts Of Industrial Forest Practices In North Carolina https://media.dogwoodalliance.org/wp-content/uploads/2019/09/Climate-Impacts-of-Industrial-Forest-Practices-in-NC-web.pdf

Greenhouse Gas Emissions: The burning of organic material sourced from trees for energy in the pulp and paper manufacturing process, including the parts of the tree that are not usable for paper, such as bark, constitutes around 40.3 percent of the overall climate impact, and fossil fuel energy use in the pulp and paper manufacturing process constitutes around 21.7 percent (for household and sanitary paper products, around 10,550 and 5,681 units of CO_2 equivalent/metric tonne of paper, respectively).[35]

Pulp and paper manufacturing accounts for 6 percent of all delivered energy consumption in the United States.[37] Delivered energy includes purchased fuels and electricity but does not account for energy produced by the burning of wood and wood by-products produced at the mill which may more than double the total energy consumption of the sector.[35] In the United States most tissue paper is manufactured at mills with integrated pulp production which uses biomass as the primary energy source.[19] While biomass reduces the need for fossil fuel use, it does not equate to reduced greenhouse gas emissions. For example, while there may be some instances of biomass energy that results in lower fossil fuels, generally when comparing technologies of similar ages, the use of woody biomass for energy will release higher levels of emissions per unit of energy than coal and significantly higher levels than gas.[38] This is due to the low heating value (the inherent energy in a fuel) and higher moisture content of wood compared to other fuels.[39]

Water Use: Pulp and paper making is an extremely water intensive process. For example, one metric tonne of tissue paper requires an average of 44,900 gallons.[40]

Water Quality Degradation: The pulping and bleaching process can also impact local water quality as the toxic chemicals often end up being discharged as effluent into waterways where they pollute rivers, harm ecosystems, bioaccumulate, and eventually enter the food chain.[35]

Air Pollution: Pulp and paper mills release air pollutants in the form of fine particulate matter (PM2.5), nitrogen oxides, sulfur dioxide, and total reduced sulfur compounds (TRS), all of which can negatively impact human health.[41]

Wood Pulping Process

Wood chips are transported to pulp mills to be processed into wood pulp. There are 35 pulp mills across the United States and Canada, located in proximity to where the most lumber is harvested.

Wood pulp[42] is a suspension of fibers made by separating the cellulose fibers from impurities in wood or other materials. Paper pulp can come from several sources, including wood (i.e., virgin tree

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[37] International Energy Outlook 2016. https://www.eia.gov/outlooks/ieo/pdf/0484(2016).pdf
[38] The Impacts of the Demand for Woody Biomass for Power and Heat on Climate and Forests. https://www.chathamhouse.org/2017/02/impacts-demand-woody-biomass-power-and-heat-climate-and-forests
[39] Does replacing coal with wood lower CO2 emissions? Dynamic lifecycle analysis of wood bioenergy. http://iopscience.iop.org/article/10.1088/1748-9326/aaa512/pdf
[40] Environmental Paper Network Calculator. https://c.environmentalpaper.org/
[41] Proximity to pulp and paper mills and wheezing symptoms among adolescents in North Carolina. https://pmc.ncbi.nlm.nih.gov/articles/PMC4517582/#:~:text=Introduction,pollutants%20released%20from%20the%20mills.
[42] Wood Pulp Mills in the US – Market Research Report (2015-2030). https://www.ibisworld.com/united-states/market-research-reports/wood-pulp-mills-industry/

fiber), postconsumer recycled content, pre-consumer recycled content, and alternative fibers such as Arundo donax, kenaf, bamboo, and wheat straw.[43]

Chemical Pulping Methods

Chemical pulping dissolves lignin, most hemicelluloses, and some cellulose at elevated temperatures.[30] Depending on the intensity of the chemical action, the fiber yield at this stage is 45-90%. Chemical pulping creates the most flexible pulp with the best fiber-to-fiber bond but creates a relatively low yield. Table 4 provides an overview of two chemical pulping methods.

Table 4: Overview of Chemical Pulping Processes

Chemical Pulping Processes	Proportion	Description	Process
Kraft Pulping	95 percent of pulping	Provides simple and efficient recovery of cooking chemicals, and allows for the possibility of bleaching and superior strength properties.	Heat wood chips in an aqueous solution of sodium hydroxide and sodium sulfide to 140-170 C followed by 3-4 hour cook time to degrade and dissolve lignin. Carbohydrates, specifically hemicelluloses, are partially degraded and dissolved, extractives are removed. Increasing sulfidity can allow for temperature reduction, which increases pulp yield.
Sulfite Pulping	< 5 percent of pulping	When used with a magnesium sulfite base, this process offers simple recovery of cooking chemicals. The pulp material is more readily and easily bleached than Kraft pulp but has inferior strength properties.	Sulfite processes use aqueous sulfur dioxide and a base (e.g., calcium, magnesium, sodium, or ammonium). Process moves through stages of pH ranges from strongly acidic to strongly alkaline in 2-3 consecutive stages.

Recovery

Once the cooking process has taken place, the spent cooking liquors are typically recovered.[30] About half of wood substances (e.g., lignin and hemicelluloses) remain dissolved in the spent liquor. At this stage, they can be recovered as biofuel. The recovery process uses combustion to recover the pulping chemicals.

In Kraft recovery, solid waste is produced in the recausticizing plant as dregs from green liquor. In sulfite recovery, sulfite liquor contains considerable amounts of acetic acid, furfural, and methanol. The evaporating vapor condensate is highly polluted and needs to be neutralized prior to

[43] Tissue. http://www.afandpa.org/our-products/tissue

evaporation. The total reduced sulfur (TRS) compounds can cause odors and "exposure has been linked to symptoms including headaches, watery eyes, nasal problems, and breathing difficulties."[44]

Fiberline

The fiberline is used to clean the fibers and prepare them to become readily useable raw material for paper production using press washers, pressure diffusers, and drum displacement washers.[30] The process includes washing, screening, oxygen delignification, bleaching, and drying. Papermaking is energy and water intensive due to the number of pulp soaking and drying processes required.[35] In addition, hazardous air pollutants (e.g., nitrous oxide, PM2.5), total reduced sulfur, and volatile organic compounds are emitted from pulping process equipment such as recovery furnaces, smelt dissolving tanks and industrial boilers.[44]

- Washing: is a chemically intensive process that uses acidic and alkaline pH treatments with alternating washing phases.
- Screening: a 3-stage reverse cascade process to remove debris from the pulp suspension, including knots, true dirt, bark, sand, shives, specks, etc.
- Cleaning: uses a centrifugal force process to separate debris particles with the same dimensions as fibers, e.g., sand or bark residues.
- Oxygen Delignification: is an important step for bleached Kraft pulp production. Lignin content of pulp is reduced, allowing Kraft pulp to regain its native color. The superoxide radical reacts with the phenolic radical, leading to ring opening, depolymerization, and increasing solubility.
- Pretreatment of Dissolving Pulp: a process used to eliminate hemicellulose from the pulp to prepare for bleaching. Kraft pulp uses a cold caustic extraction while sulfite pulping uses hot caustic extraction.
- Bleaching: is a process that includes delignifying, hot acid treatment, and ozone treatment, used to produce a bright product (i.e., for printing purposes), and to remove dots, specks, and shives. This allows the paper to produce good run ability on machines, reduce hypoallergenic reactions in hygiene products, and soften tissue fibers. Up to 85% of the total effluent volume discharged from a pulp mill is generated during bleaching.[45]
- Drying: the final step in the fiberline is for the pulp to be dried, pressed, and cut to prepare it for transportation to the paper mill. Paper drying accounts for up to 70% of fossil fuel energy use in the pulp and paper sector and represents one of the largest sources of non-biological CO_2 emissions[46] in the broader forest fiber industry.[35]

Mechanical Pulping

About 20 percent of pulping processes use mechanical methods. The mechanical defibration of wood is an energy intensive process that achieve yields of 80-95%.[30] The process uses refining and grinding to plasticize lignin and remains in the pulp. Mechanical pulping causes less stable

[44] Life Cycle Impact Assessment Methodology for Environmental Paper Network Paper Calculator v4.0. https://c.environmentalpaper.org/pdf/SCS-EPN-PC-Methods.pdf
[45] Best Available Techniques (BAT), Reference Document for the Production of Pulp, Paper and Board. https://eippcb.jrc.ec.europa.eu/sites/default/files/2019-11/PP_revised_BREF_2015.pdf
[46] Unfold the Future: The Forest Fibre Industry, 2050 Roadmap to a low-carbon bio-economy. https://www.cepi.org/wp-content/uploads/2020/08/2050_roadmap_final.pdf

brightness, lower strength, low resistance to aging, and tendency to discolor. Mechanical pulp keeps most of the lignin compounds in the fibers and requires bleaching using chemicals of limited aggressiveness.

Product Manufacturing

Once pulp has been dried, pressed, and prepared, it is ready to be transported to one of 100+ paper mills across the U.S. and Canada. Paper mills can be fully integrated mills or nonintegrated mills. Integrated mills consist of a pulp mill and a paper mill on the same site. Such mills receive logs or wood chips and produce paper.

At the paper mill, parent rolls are cut into sizes for individual sale, packaged, boxed, and prepared for distribution. Printing and converting constitute around 7.2 percent of paper production and consumption's climate impact (for household and sanitary paper products, around 1,884 units of CO_2 equivalent/metric tonne of paper).[35]

Distribution Stage

Transportation. The distribution of household and sanitary paper products involves moving finished goods to retailers and commercial and institutional settings. The main impact of this phase is the greenhouse gas emissions associated with burning fuel; the amount of greenhouse gas emissions generated from this transport depends on the distance traveled, the amount of product shipped, and the frequency of trips over a given time period. Overall transportation and distribution accounts for 8.5% of the total climate impact of paper products.[35,47]

Use Stage

Quality of Product and Functional Performance. The largest impact of the use stage of household and sanitary paper products is related to performance: products should work as intended, provide adequate absorption, and allow users to maintain proper hygiene without having to "overuse" the product.

Disposal and End-of-Life Stages

While many paper and paperboard products can be recovered and recycled, household and sanitary paper products are single-use hygienic products. While toilet tissue is designed to disintegrate readily when flushed down the toilet, other household and sanitary paper products such as paper towels, facial tissue, and napkins enter the waste stream and take several weeks to decompose in the landfill. This is distinct from all other paper and paperboard categories, which have high rates of recycling compared to metal, glass, and plastic. Approximately 65-69% of paper and 71-76% of cardboard was recycled in the United States in 2023.[48]

Household and sanitary paper products decompose in a landfill over the course of several weeks. Landfilling of paper constitutes around 10.6% of paper production and consumption's climate impact

[47] Note: the climate impact of transportation / distribution is negligible to the point that it is included in an "other" category, totaling 8.5 percent, which includes harvesting vehicle emissions and transport.
[48] Paper Industry Announces 2023 U.S. Paper Recycling Rates Using Updated Methodology. https://www.afandpa.org/news/2024/paper-industry-announces-2023-us-paper-recycling-rates-using-updated-methodology

(for household and sanitary paper products, around 2,600 units of CO_2 equivalent/metric tonne of paper).[35]

Reducing Impacts by Using Recycled Material or Alternative Fibers

Recycled Fibers

In the United States, landfills are the largest emitters of methane, a potent greenhouse gas.[49] Paper and paper products represent a significant percentage, 23.1% by weight, of overall waste in the United States.[50] U.S. tissue manufacturers are major consumers of recycled paper. In 2017, over four million tons of recycled paper was utilized by U.S. manufacturers to produce 7.6 million tons of new tissue products (55 percent of total production volume). Of the recycled paper grades available for use in tissue product production, most recycled fiber utilized comes from deinking grades (see Table 5).[19]

Table 5: Distribution of Recycled Paper Consumption by U.S. Tissue Manufacturers (2017)

Recycled Material Source	Percentage of Total Recycled Material	Number of Tons of Recycled Material
Mixed Paper	17%	680,000
Newsprint	10%	400,000
Corrugated	7%	280,000
High Grade Deinking	56%	2,240,000
Pulp Substitutes	10%	400,000
Total	100%	4,000,000

With household and sanitary paper consumption expected to increase globally, it is important to understand how mitigation strategies, such as reducing virgin content, will affect greenhouse gas emissions and other environmental impacts. Recycling paper products has clear, quantified environmental benefits. Studies show that incorporating recycled content into paper products results in net reductions of greenhouse gas emissions by eliminating emissions associated with the harvesting and pulping of virgin material. For example, using 100 percent recycled content compared with 100 percent virgin content reduces over 70 percent of the greenhouse gas emissions per ton of tissue produced.[44]

In addition to greenhouse gas emissions reductions, a host of other environmental impacts are reduced through integrating higher levels of recycled content into sanitary paper and tissue products. Table 6 provides a summary of 100% virgin versus 100% recycled content tissue from the Life Cycle Impact Assessment Methodology for Environmental Paper Calculator v4.0,[44] using data and modeling to calculate the North American average results.

[49] The Landfill and Climate Change. http://thepaperlifecycle.org/end-of-life/in-depth/the-landfill-and-climate-change/
[50] Guide to the Facts and Figures Report about Materials, Waste and Recycling. https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/guide-facts-and-figures-report-about

Table 6: North American Average Results for Environmental Impacts of Tissue

Impact	100% Virgin	100% Recycled
Nitrogen Oxides (NOx) Forming Ground Level Ozone/ Ground Level Ozone (in M-CF[51])	122	34
Particulates/PM 2.5 Impacts (in M-CF)	858	35
Ocean Acidification (pounds H_2CO_3 per ton paper)	6,146	1,554
Greenhouse Gas Impacts (pounds CO_{2e} per ton paper)	26,184	8,124

There are additional impacts associated with using recycled content in sanitary paper products due to the need to deink and repulp the paper materials. For example, deinking and pulping processes of recycled content can generate higher volumes of wastewater. “Sludge generated from the deinking process contains minerals, coatings, fillers, ink particles and deinking additives, resulting in BOD, COD and TSS generations. Therefore, the BOD and COD results for some recycled paper grades are higher compared to virgin paper grades.”[44]

The market for recycled fiber has undergone dramatic changes in recent years. Digitalization, the shift from using printing and writing paper to going paperless, has had a significant impact on the available supplies of recycled fiber. Between 2000 and 2018, printing and writing production in the United States and Canada decreased by half (Figure 2). The COVID-19 pandemic further impacted recycled fiber supplies.[52] Production of printing and writing paper is projected to decrease 50-75% compared to 2020 levels by 2032 which will further decrease the supply of recycled fiber available to produce tissue products.[53] Old corrugated containers (OCC) are a potential replacement for recycled fiber in tissue products. However, processing OCC presents challenges due to the fiber color and reduced softness of the fibers compared to printing and writing paper. Alternative fibers (e.g., wheat straw, bagasse, bamboo, etc.) are another potential replacement for the dwindling supply of printing and writing paper. The use of alternative fibers will be discussed further in the following section.

[51] Midpoint Characterization Factor (M-CF): A factor which characterizes the actual effect on the receiving environment of emissions, resource uses, or land uses. Multiplied with Potency Potential Characterization Factors (PP-CFs) to calculate results.
[52] Recovered Paper Supply – Already in Decline – Hit Hard by the Pandemic. https://www.tissueworldmagazine.com/departments/exitissues/recovered-paper-supply-already-in-decline-hit-hard-by-the-pandemic/
[53] Unveiling the future – the hygiene tissue industry in the next decade. https://www.tissueworldmagazine.com/special-features/enhancing-sustainability-metrics-for-hygiene-tissue-products/

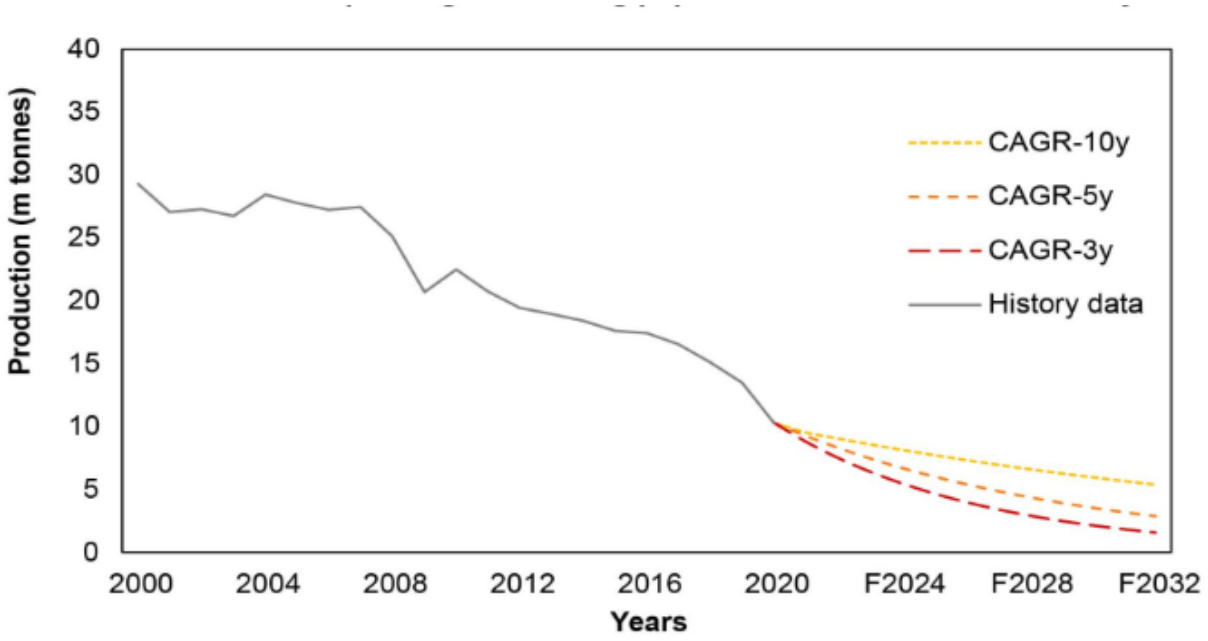

Figure 2. Production of Printing and Writing Papers in the U.S. and Canada[53]

Alternative Fibers

Using alternative fibers (or "tree free" fibers) can help preserve forests and reduce the environmental impact of sanitary paper products. Forests serve as "carbon sinks" that store carbon by sequestering carbon dioxide. Old growth forests in particular are an effective terrestrial carbon sequestration system containing 35% higher carbon stocks than logged forests on average and have an estimated 40 times higher sequestration potential per hectare over the next century.[54]

Tissue pulp can be made from alternative fibers including bamboo, kenaf, wheat straw, and bagasse.[55] While manufacturers should strive to maximize use of recycled content in their paper products, sustainably sourced alternative fibers can be a sustainable substitute for virgin wood pulp. Green Seal's Standard for Sanitary Paper Products currently includes a certification path for agricultural residues (e.g., wheat straw and bagasse). As part of this standard revision, Green Seal assessed whether to expand certification offerings to include a path for sustainably sourced bamboo given the market for bamboo tissue products has been rapidly increasing in recent years.

According to peer-reviewed life cycle analyses, bamboo has a smaller environmental footprint than virgin forest fiber but a larger footprint than recycled fiber and some alternative fibers.[3,4] For example, bamboo tends to have a higher environmental footprint than wheat straw because bamboo is a purpose-grown crop whereas wheat straw is a residue material or byproduct.[17] Some of the key advantages of bamboo compared to virgin forest fiber include that bamboo has a high site

[54] Taking the pressure off irreplaceable forests. https://www.datocms-assets.com/132613/1727123752-canopy_nextgenbenefitsbrief_2024.pdf

[55] Responsible Fiber Alternatives Assessment Methodology. http://www.worldwildlife.org/publications/responsible-alternative-fibers-assessment-methodology

productivity and grows very quickly. For example, some bamboo species can grow over 36 inches within 24 hours and bamboo regenerates over 20 times faster than northern softwood.[3,56]

The sourcing of bamboo is critical when evaluating whether it is an appropriate alternative fiber. While alternative fibers, such as bamboo, provide real potential to reduce stress on forests and protect high conversation value and high carbon storage potential forests, there are potential sourcing impacts to consider.[57] According to the World Wildlife Fund, "poor site selection and management could create the need for additional water use, cause pollution from excess chemical or fertilizer use, and even result in the conversion of natural forests. If a non-native species is selected for alternative fiber development it could become invasive, displace native species, or host invasive pests."[55] The Forest Stewardship Council (FSC) and Roundtable for Sustainable Biomaterials (RSB) offer certifications that help mitigate sourcing impacts. For example, both certifications protect against the conversion of natural forests, conserve other sensitive or high conservation value (HCV) areas, require certificate holders to implement a site management plan based on risks associated with site operations, and address pesticide and fertilizer use.[58,59] In addition, these certifications address the social impacts of sourcing including human and labor rights; land rights; and Free, Prior, and Informed Consent (FPIC).

The integrity of bamboo supply chains is another potential risk with bamboo products. A recent analysis of five bamboo brands found that some "100% bamboo" products contained as little as 2.7% bamboo fiber.[60] Subsequently, the FSC and one of their certification bodies, Assurance Services International (ASI), launched investigations to evaluate integrity risks.[61,62] These investigations reviewed the supply chains of 425 certificate holders and identified some instances of noncompliance. As a result, several certificate holders were blocked.

FSC has acknowledged that there may be additional integrity risks and is continuing its investigations. FSC is currently working to revise its chain of custody standard and will strengthen its framework based on observations from these investigations.[63] Several brands have noted that they are testing fiber used in their products using TAPPI T 401 – Fiber Analysis of Paper and

[56] Merits of bamboo utilization in earth preservation, water, and wastewater treatment: A mini review. https://bioresources.cnr.ncsu.edu/resources/merits-of-bamboo-utilization-in-earth-preservation-water-and-wastewater-treatment-a-mini-review/
[57] Canopy Planet: Bamboo Position Paper. https://www.datocms-assets.com/132613/1740094210-canopy_bamboo_position_2025.pdf
[58] FSC Principles and Criteria for Forest Stewardship Standard. https://connect.fsc.org/document-centre/documents/resource/392
[59] RSB Principles & Criteria. https://rsb.org/wp-content/uploads/2024/05/rsb-principles-criteria-std-01-001-v4-1.pdf
[60] Which? testing finds some bamboo toilet paper actually made with wood. https://www.which.co.uk/news/article/which-testing-finds-some-bamboo-toilet-paper-actually-made-with-wood-apn2u4Y7Pfdr
[61] Integrity Risks Identified in Bamboo Supply Chains. https://fsc.org/en/newscentre/integrity-and-disputes/integrity-risks-identified-in-bamboo-supply-chains
[62] Investigation into bamboo toilet paper. https://www.asi-assurance.org/s/post/a1JS7000000te4rMAA/p1254
[63] Revision of Chain of Custody Standards and FSC-STD-20-011 Chain of Custody Evaluations. https://connect.fsc.org/current-processes/revision-chain-custody-standards-and-fsc-std-20-011-chain-custody-evaluations

Paperboard.[64] This testing is a cost-effective means for brands to ensure the integrity of their supply chains.

Protecting Human Health and Preventing Environmental Pollution

PFAS. PFAS are a unique group of human-made chemicals whose strong carbon-fluorine bonds confer the ability to repel water and grease in food packaging, paints and coatings, firefighting foam, cookware, textiles, and several other product categories. Their unique chemical structure also makes them very resistant to breaking down in the environment. As a result, PFAS have been found around the world in the environment, wildlife, and human bodies and have been associated with health and environmental harms. PFAS used as raw materials or processing agents can be released as emissions or into wastewater streams, and "current emission filters do not completely capture them, nor is there an effective means of disposing of captured PFAS."[65]

Releases of PFAS in the environment have long-term consequences because PFAS can have such long half-lives – the time in which 50 percent of the chemical is expected to degrade. For example, some PFAS polymers have estimated half-lives of over 1,000 years in soil.[5,66] These long half-lives also mean PFAS can travel far distances from their original release into the environment[67,68] — a problem not specific to long-chain PFAS. Short-chain PFAS have also been detected in waterbodies and, in some cases, were found to be more persistent in aquatic systems.[69,70] PFAS contamination has been widely documented in waterbodies across the U.S. and globally. It is estimated that some level of PFAS is now found in all U.S. drinking water supplies that use surface water, with one study finding 1,400 sites in 49 U.S. states containing PFAS contamination in drinking water.[71] A report from 2023 estimates that almost half of the nation's drinking water sources have one or more types of PFAS.[5] The widespread contamination of PFAS has also been shown to result in bioaccumulation in plants and animals. For example, PFOS can build up in fish, birds, and other marine mammals,[72] and it is expected that some PFAS would be found in samples from any wild animal.[73] Plants can also accumulate PFAS when grown in contaminated soil or irrigated with contaminated water.[74,75] While less is known about effects on wildlife than in humans, exposure to PFAS has been

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[64] Fiber Analysis of Paper and Paperboard, Test Method TAPPI/ANSI T 401 om-20 https://imisrise.tappi.org/TAPPI/Products/01/T/0104T401.aspx

[65] Kissa E. Fluorinated surfactants and repellents, vol. 97. 2nd ed. New York: Marcel Dekker, Inc.; 2001

[66] Degradability of an acrylate-linked, fluorotelomer polymer in soil. https://doi.org/10.1021/es9002668

[67] A global survey of perfluorinated acids in oceans. https://pubmed.ncbi.nlm.nih.gov/15913661/

[68] Atmospheric perfluorinated acid precursors: chemistry, occurrence, and impacts. https://link.springer.com/chapter/10.1007%2F978-1-4419-6880-7_1

[69] Short-chain per- and polyfluoroalkyl substances in aquatic systems: Occurrence, impacts and treatment. https://doi.org/10.1016/j.cej.2019.122506

[70] Chapter 14 - Analysis of GenX and Other Per- and Polyfluoroalkyl Substances in Environmental Water Samples. https://www.sciencedirect.com/science/article/abs/pii/B9780128157305000144

[71] Per- and polyfluoroalkyl substances and fluorine mass balance in cosmetic products from the Swedish market: implications for environmental emissions and human exposure. https://doi.org/10.1039/C8EM00368H

[72] U.S. EPA Long-Chain Perfluorinated Chemicals (PFCs) Action Plan. https://www.epa.gov/sites/default/files/2016-01/documents/pfcs_action_plan1230_09.pdf

[73] Environmental and Health Impacts of PFAS. https://dnr.wisconsin.gov/topic/PFAS/Impacts.html

[74] Uptake of Perfluorinated Alkyl Acids by Hydroponically Grown Lettuce (Lactuca sativa). https://doi.org/10.1021/es302398u

[75] Scientific Basis for Managing PFAS as a Chemical Class. https://doi.org/10.1021/acs.estlett.0c00255

associated with adverse effects such as toxicity, effects on immune function,[76,77] and even impacts on subsequent generations of organisms.[78]

In addition to the ecological consequences, the presence of PFAS as an environmental pollutant ultimately becomes another exposure pathway for human health through the ingestion of drinking water and contaminated food sources like fish and game. Green Seal has determined that eliminating PFAS from the supply chain is critical to preventing pollution that will persist for decades and continue to be a challenge to remediate.

Humans are exposed to PFAS through several avenues, including drinking water, food, and the use of consumer products. This potential chronic exposure, coupled with the fact that many PFAS do not leave the human body for years,[79] has led to PFAS being found in the blood of nearly all humans, even newborns, in the U.S. and other countries around the globe.[80,81]

Of the overall PFAS chemical class, PFOA and PFOS have received the most study and are both associated with several adverse health outcomes. PFOA has been designated as a probable carcinogen[82] and has been associated with increased risk of testicular and kidney cancer, as well as several other conditions such as ulcerative colitis, thyroid disease, and impacts on pregnancy.[83] PFOS has been shown to cause "hepatotoxicity, neurotoxicity, reproductive toxicity, immunotoxicity, thyroid disruption, cardiovascular toxicity, pulmonary toxicity, and renal toxicity in laboratory animals and many in vitro human systems."[84] Both chemicals have been found to cause "reproductive effects such as decreased fertility…; developmental effects or delays in children…; increased risk of some cancers, including prostate, kidney, and testicular cancer…; reduced ability of the body's immune system."[85] While the manufacturing and use of PFOA and PFOS has been mainly phased out in the U.S., many of the short-chain chemicals meant to replace these two chemicals also display concerning health impacts. For example, Perfluorobutane sulfonic acid (PFBS), meant to replace

[76]Immunotoxicity in green mussels under perfluoroalkyl substance (PFAS) exposure: Reversible response and response model development. https://setac.onlinelibrary.wiley.com/doi/10.1002/etc.4060
[77] Elevated levels of per- and polyfluoroalkyl substances in Cape Fear River Striped Bass (*Morone saxatilis*) are associated with biomarkers of altered immune and liver function.
https://www.sciencedirect.com/science/article/pii/S0160412019334762
[78] Fate and effects of poly- and perfluoroalkyl substances in the aquatic environment: A review.
https://setac.onlinelibrary.wiley.com/doi/10.1002/etc.2663
[79] Breaking It Down: Estimating Short-Chain PFAS Half-Lives in a Human Population.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7657368/#c4
[80] Maternal serum concentrations of perfluoroalkyl acids in five international birth cohorts.
https://pubmed.ncbi.nlm.nih.gov/28063899/
[81] Fourth National Report on Human Exposure to Environmental Chemicals Updated Tables, March 2021, Volume three.
https://stacks.cdc.gov/view/cdc/105344
[82] Perfluorooctanoic Acid (PFOA), Teflon, and Related Chemicals. https://www.cancer.org/cancer/cancer-causes/teflon-and-perfluorooctanoic-acid-pfoa.html
[83] Probable Link Evaluation of Birth Defects.
http://www.c8sciencepanel.org/pdfs/Probable_Link_C8_Birth_Defects_5Dec2011.pdf
[84] Assessing the human health risks of perfluorooctane sulfonate by in vivo and in vitro studies.
https://doi.org/10.1016/j.envint.2019.03.002
[85] Our Current Understanding of the Human Health and Environmental Risks of PFAS. https://www.epa.gov/pfas/our-current-understanding-human-health-and-environmental-risks-pfas

PFOS, has been shown to have impacts on the thyroid,[86] and a chemical by the trade name of GenX, meant to replace PFOA, has been associated with "hepatic and renal effects and suppressed immune function in mice."[65]

Of particular concern is the effects of PFAS on human development and thus vulnerable populations, such as those who are pregnant and children. Many studies have documented associations between PFAS and "adverse immune outcomes" in children.[81] For example, exposure to PFAS has been associated with reduced antibody responses to vaccinations: "children exposed to higher levels of PFAS during development had a reduced immune response to routine tetanus vaccination."[13] Additional impacts on children and pregnancy include delayed puberty in children exposed to PFAS while in utero,[87] lower birthweights,[88] and pregnancy-induced hypertension.[89]

Paper mills are a potential source of PFAS contamination.[90] A recent study found toilet paper to be a source of PFAS in wastewater and noted the most prevalent PFAS detected in the toilet paper and sewage sludge was 6:2 fluorotelomer phosphate diester, or 6:2 diPAP.[91] DiPAPs are precursors and have the potential to be transformed into more persistent PFAS such as perfluoroalkyl carboxylic acids (PFCAs).[92,93] The manufacturing process is a potential source of DiPAP introduction. As part of Green Seal's work to address PFAS as a group of hazardous chemicals across Green Seal product categories,[15,16] PFAS will be prohibited in functional papermaking additives used to produce certified products.

Chlorine-free Bleaching. For several decades, elemental chlorine, chlorine dioxide, and sodium hypochlorite were used to bleach printing and writing paper and tissue products to make those products appear bright white and to soften the fibers. However, in the mid-1980s, it was discovered that when chlorine interacts with the organic compounds in wood products it can form harmful by-products such as dioxins, chloroform, and other halogenated organic compounds. Commonly this group of compounds is referred to and measured as adsorbable organically bound halogens (AOX).[94] The main pathway of environmental exposure of these compounds from using chlorine-based additives in the pulping process is through wastewater effluent discharged from paper mills. Dioxins are persistent organic pollutants that bioaccumulate in the food chain in addition to being

[86] Learn about the Human Health Toxicity Assessment for PFBS. https://www.epa.gov/chemical-research/learn-about-human-health-toxicity-assessment-pfbs
[87] PFAS the 'Forever Chemicals' Invisible threats from persistent chemicals. https://chemtrust.org/wp-content/uploads/PFAS_Brief_CHEMTrust_2019.pdf
[88] PFAS Explained. https://www.epa.gov/pfas/basic-information-pfas
[89] C8 Probable Link Reports. http://www.c8sciencepanel.org/prob_link.html
[90] Suspected industrial discharges of PFAS. https://www.ewg.org/interactive-maps/2021_suspected_industrial_discharges_of_pfas/map/
[91] Per- and Polyfluoroalkyl Substances in Toilet Paper and the Impact on Wastewater Systems. https://pubs.acs.org/doi/full/10.1021/acs.estlett.3c00094
[92] Per- and polyfluoroalkyl substances in the environment. https://www.science.org/doi/10.1126/science.abg9065
[93] Production of Perfluorinated Carboxylic Acids (PFCAs) from the Biotransformation of Polyfluoroalkyl Phosphate Surfactants (PAPS): Exploring Routes of Human Contamination. https://pubs.acs.org/doi/10.1021/es070126x
[94] European Environment Agency: Halogenated Organic Compounds (AOX). https://www.eea.europa.eu/help/glossary/eper-chemicals-glossary/halogenated-organic-compounds-aox

highly toxic to humans and aquatic life.[95] Chloroform is a carcinogen that can have multiple health effects.[96]

In the 1990s, the U.S. EPA began regulating dioxin emissions resulting from the use of elemental chlorine bleach in pulp and paper production.[97] As a result, the industry has phased out the use of elemental chlorine as a bleaching agent. More than 95% of worldwide pulp production uses Elemental Chlorine Free (ECF) bleaching, which uses chlorine dioxide instead of elemental chlorine in the bleaching process.[98] The ECF bleaching process significantly reduces the production of dioxins, furans, and other chlorinated organic compounds.[99] Totally Chlorine Free (TCF) bleaching uses oxygen-based agents or hydrogen peroxide to facilitate the bleaching process, eliminating any possibility of dioxin or furan production.[100] However, TCF bleaching processes are much less common, representing only about three percent of worldwide pulp production.[98] Due to the limited availability of TCF bleached alternative fiber pulp, Green Seal proposes to allow ECF bleaching for agricultural residue or bamboo. Green Seal encourages manufacturers to continue to invest in their supply chains, including prioritizing improvements that reduce the environmental impacts of bleaching processes. Green Seal may consider revising the bleaching criteria for alternative fibers as more TCF bleached pulp becomes available.

Low-Impact Manufacturing

The manufacturing phase is a significant contributor to the life cycle impacts of sanitary paper products. For example, papermaking is an extremely energy and water intensive process. Paper manufacturing is the third largest energy consuming manufacturing sector after chemicals and petroleum and coal products.[101] Additionally, the global pulp and paper industry consumes over 24 billion gallons of water per day.[102]

An environmental management system (EMS) can help reduce the environmental impacts of the manufacturing phase by ensuring that a company has policies and procedures in place to accurately measure their impacts and a system to improve over time. ISO 14001 is an internationally recognized standard for EMS that provides a framework for organizations to develop and implement an EMS and continually improve their environmental performance.[103] Green Seal proposes to

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[95] EPA: Learn About Dioxin. https://www.epa.gov/dioxin/learn-about-dioxin
[96] Bleaching Agents – Pulp and Paper Industry. https://repository.gatech.edu/server/api/core/bitstreams/1c25a335-a4ad-463a-8cc3-9642a0eac6d6/content
[97] EPA to Regulate Dioxin in Paper Industry. https://www.epa.gov/archive/epa/aboutepa/epa-regulate-dioxin-paper-industry.html
[98] Facts About the Use of Bleaching Agents in Tissue and Paper Towel Manufacturing. https://www.afandpa.org/sites/default/files/2023-02/FactsAboutBleachingAgents.pdf
[99] Stockholm Convention on Persistent Organic Pollutants: Guideline on best available techniques and guidance on best environmental practices relevant to Article 5 and Annex C of the Stockholm Convention: section V.C on production of pulp using elemental chlorine or chemicals generating elemental chlorine. https://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-TOOLKIT-BATBEP-2022-1-4.English.pdf
[100] Effect of Recycled Fiber Use on Chlorinated Compounds. https://www.paperenvironment.org/PDF/recycling/chcompounds/R_C_Bleach.pdf
[101] Energy Use in Industry. https://www.eia.gov/energyexplained/use-of-energy/industry.php
[102] Benchmarking Water Usage: An Increasingly Important Metric for Pulp and Paper Producers. https://www.resourcewise.com/forest-products-blog/benchmarking-water-usage-an-increasingly-important-metric-for-pulp-and-paper-producers#:~:text=Pulp%20and%20paper%20is%20a,3%20of%20water%20per%20day
[103] ISO 14001:2015. https://www.iso.org/standard/60857.html

require manufacturers to develop and implement an EMS. Manufacturers may submit documentation to demonstrate their system contains the minimum elements specified in the standard or provide a valid certification such as ISO 14001. Additionally, the EMS criteria will require manufacturers to report and comply with energy and water use thresholds while also tracking and reducing greenhouse gas emissions.

Verified Performance

Green Seal is committed to performance as an aspect of safer and more sustainable products. As part of this revision, Green Seal evaluated the standard's performance criteria to ensure the standard covers the right attributes to demonstrate a minimum industry level of performance. The existing standard includes the following attributes: basis weight, tensile strength (dry and wet), stretch, and water absorbency. Based on this evaluation and consultation with our group of market and technical experts, Green Seal identified the following key changes:

1. Removal of the basis requirements: Green Seal received feedback that while basis weight can offer insights into absorbency or strength, basis weight may not be the best indicator of performance because it is simply a calculation based on fiber usage. Thus, Green Seal proposes to remove the basis weight requirements and instead focus on attributes that directly impact product performance (e.g., dry and wet tensile strength, stretch, and water absorbency).
2. Updates to the test methods referenced in the standard:
    a. Green Seal currently references the TAPPI method for T 576: Tensile properties of towel and tissue products (using constant rate of elongation apparatus). The T 576 test method has been withdrawn and replaced with T 581: Dry tensile properties of paper towel and tissue products (using constant rate of elongation apparatus). Green Seal proposes to update the references to T 576 in the standard to T 581.
    b. Green Seal currently references TAPPI T 494: Tensile properties of paper and paperboard (using constant rate of elongation). However, Green Seal received feedback that it would be more appropriate to reference TAPPI T 581: Dry Tensile Properties of Paper Towel and Tissue Products (using constant rate of elongation) because T 581 is written specifically for tissue and towel samples whereas T 494 is written for paper and containerboard. For example, T 581 gives guidance on preparation of tissue samples and test specimen dimensions which may be different than that for higher basis weight papers.
    c. Green Seal currently references ISO 1924-3:2005 Paper and board – determination of tensile properties. However, Green Seal received feedback that it would be more appropriate to reference ISO 12625-4:2022 Tissue paper and tissue products – Part 4: Determination of tensile strength, stretch at maximum force and tensile energy absorption and ISO 12625-5:2024 Tissue paper and tissue products – Part 5: Determination of wet tensile strength because these test methods are specific to tissue products and include special considerations for these types of papers.
3. Updates to the Performance Thresholds:

a. Green Seal proposes a few adjustments to the thresholds for dry tensile strength and stretch to better reflect accurate performance for this product category. In addition, Green Seal proposes removing the stretch requirements for toilet seat covers as stretch is not a relevant performance characteristic for this product type.