The Carbon Footprint of two virgin fiber paper packaging mills in the Mid-Atlantic Coastal Ecosystem

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Introduction

This report details the climate impact of two large virgin fiber paper packaging mills located in the Southern United States. The Southern United States is the largest paper and wood producing region in the world and across the Southern landscape the forest products industry's demand for wood fiber is a powerful factor driving forest management practices. The industry's impact on the ecological values of the region's forests has long been recognized; less understood and less visible is the sector's impact on our climate. Using conservative methodology to analyse the flow of carbon from the forests through the mills and into the final paper product itself, this report concludes that the true carbon footprint of this industry is enormous.

The large climate impact of these mills alone serves to highlight the fundamental importance of conserving the existing carbon stocks held in our forests and in improving the ability of these forests to buffer us from climate change through increased carbon sequestration going forward. Logging and forest management decisions are also carbon and climate change decisions. Based on this knowledge we know that our decisions concerning our paper and other forest product choices are important to the climate.

Paper is a product that is ubiquitous in our lives, from packaging to copy paper, advertising in catalogues and elsewhere, books, tissue and many other products. It is understandable that we expect paper production to have a big climate impact. The impact is often greater than our expectations. In essence, forests are important biological scrubbers working to buffer us from climate change by removing (sequestering) CO2 from the atmosphere. Human impacts on forests limit and decrease these ecosystem's ability to hold carbon. In particular, the manufacturing of pulp and paper from wood taken from forests is a significant draw-down on forest carbon stores. Trees take carbon dioxide from the atmosphere as they grow and store that carbon safely away from the atmosphere. And as they grow, from the time of last harvest, forests become more and more able to absorb carbon dioxide over a considerable period – from the small trees with their few leaves and small biomass that are poor carbon sequestration tools, to the large, carbon absorbers that are healthy second growth forests. Paper-making reverses that process.

Harvesting these forests and using the majority of the carbon held in the trees for energy releases most of that carbon dioxide back into the atmosphere where it has a big – and negative – climate impact. Instead of cycling carbon from the atmosphere into the trees, we cycle carbon back into the atmosphere. Not surprisingly, the biomass component of virgin paper production has the largest negative impact on the climate of any segment of the paper production cycle.

Carbon sequestration on forest lands depend on the management practices adopted, and management decisions can reduce the negative impact of paper production on the carbon to carbon dioxide cycle. In addition, forest management can result in positive carbon benefits. The key strategies for improving the climate profile in forest management – if we consider harvest of wood for paper a necessity – are:

- leaving trees and forests undisturbed for longer periods, extending rotations, so that the carbon storage across the landscape is increased;
- protecting key ecosystems and portions of stands within the forest and land matrix which will not only protect the carbon in those places, but provide other benefits such as wildlife habitat and the protection of streams and rivers;
- adopting lower impact harvest methods that protect non-target trees and the carbon on the forest floor by reducing cut-block sizes and protecting dead wood, both standing and on the ground.

Two recent articles in *Science* magazine summarize our dilemma in an era of climate change. One study demonstrated the clear threat of depending on biomass for energy. Dependence on biomass will simply lead to a greater draw-down on forest resources, on natural forests and lead to wide-spread conversion to short-cycle carbon.[1] This strategy will mean that across the landscape, less and less carbon will be stored and put more of that carbon into the atmosphere. Ironically, this could damage the paper industry in the end, since there will be less and less forest resource to make paper and

Fixing a Critical Climate Accounting Error

> **"[Current carbon accounting methodology] erroneously treats all bioenergy as carbon neutral regardless of the source of the biomass, which may cause large differences in net emissions. For example, the clearing of long-established forests to burn wood or to grow energy crops is counted as a 100% reduction in energy emissions despite causing large releases of carbon."**

– Searchinger, Timothy, et al. 'Fixing a Critical Climate Accounting Error.' *Science*, Vol. 326, 23 October 2009.

drive the cost of those resources up as energy production moves from fossil fuels where the environmental price is revealed, to biomass energy production, where the environmental price is hidden. The second recent *Science* article outlined the futility of the biomass-for-energy strategy: the carbon dioxide will still be in the atmosphere, but it will come at the expense of landscape carbon storage rather than from fossil fuels.[2]

Calculating the Climate Impact of a Product

A Carbon Footprint is a measure of the impact of a particular product or service on the climate. It is useful in making determinations about which products we prefer to consume or how to change a product in question to lower its total impact on the climate. A Carbon Footprint indicates the consequences of the choices we make with respect to the products and services we consume.

We must be clear that we must lower our impact on the climate in two significant areas: in emitting greenhouse gases from fossil fuels, and in limiting our impact on carbon-storing ecosystems, especially forests. Forests at one time held far greater levels of carbon within them, but society over time has released much of that carbon into the atmosphere through degrading and converting them – results of our collective management decisions.[3] The impact is measured in terms of the Global Warming Potential (GWP)[1] of the effect on the atmospheric levels of greenhouse gases of the product or service. The standard unit of measure is carbon dioxide equivalents (CO_2e), since carbon dioxide is the most common greenhouse gas. Other greenhouse gases are also measured and converted to CO_2e and are included in the carbon footprint to the extent possible.

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[1] Global Warming Potential (GWP) is a rating over a 100 year period of the efficiency of a particular greenhouse gas at trapping heat and thus causing additional warming. The IPCC 2006 Guidelines for National Greenhouse Gas Inventories is the definitive source for this coefficient.

The process of assessing the carbon footprint of these mills will include:

1. Drawing the boundaries of the system. The system boundaries are all those energy sources and processes that affect atmospheric levels of greenhouse gases used to produce a product.
2. Use the most accurate data and sources available. This analysis is based on publicly available data and North American production averages used in the Paper Calculator for greenhouse gas released at the pulp and paper production site.
3. Use IPCC formulae to calculate impacts at the forest level.[2] Due to the dynamic nature of ecosystem carbon over time, thus bringing into question the accuracy of the estimate, we need to be sure that the resulting estimate of our methodology is a conservative one.
4. Compare these results to North American averages for the equivalent 100% recycled products.

System Boundaries

The system boundaries for the present study are limited to the production process of the products. The boundaries begin with the sourcing of the raw materials and energy, continues through delivery of those raw materials, and through the production process itself. The product's end-life is also important, since one needs to balance harvest emissions with storage of harvested wood products. Including product end-of-life we also take into account the inherent (given the recycling and waste disposal system as it currently exists) impact of creating these products. The latter concept is an application of the principle of Extended Producer Responsibility.[3]

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[2] The Intergovernmental Panel on Climate change produces methodologies and analysis under the auspices of the UN Framew Convention on Climate Change. It is a body composed of leading scientists on climate change issues from the many countries.

[3] For background on Extended Producer Responsibility, see the Institute for Local Self-Reliance web site http://www.ilsr.org/recycling/epr/index.html.

Paper production segments

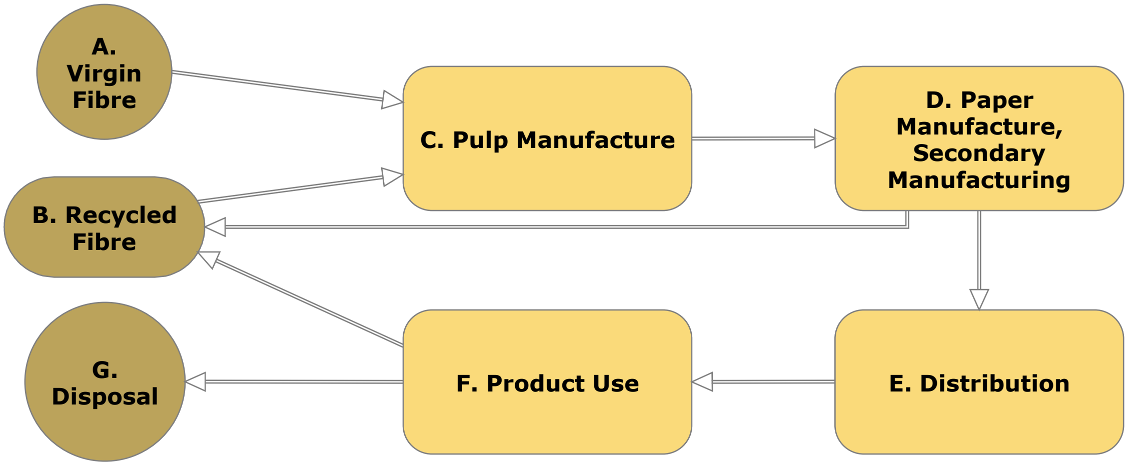
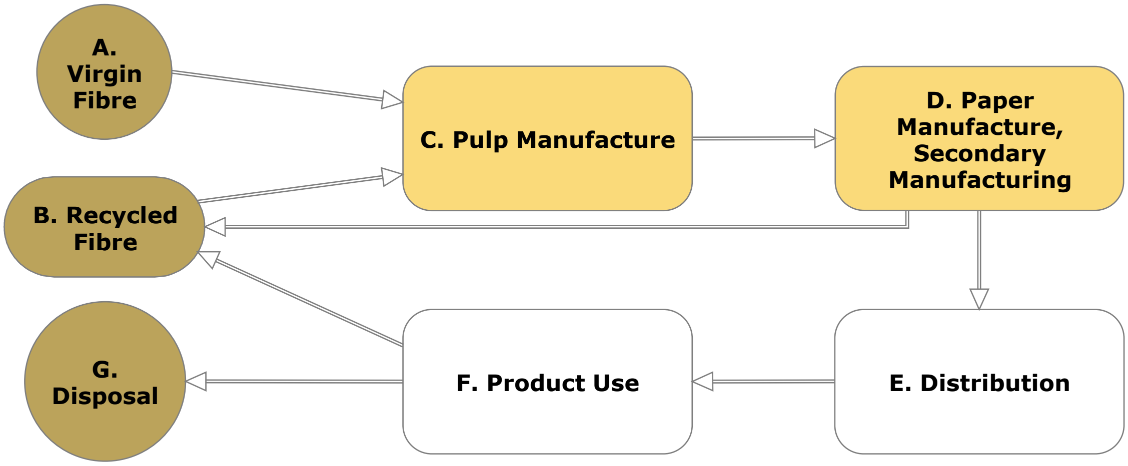


Figure 1, 'Paper production segments,' depicts a simplified version of paper products: raw material sourcing, production, consumption and disposal. Raw material sourcing includes segments A and B, where either virgin or recycled fiber are procured. Segments C and D encompass the manufacture of the products from raw materials to finished products and incorporates all inputs to the process such as energy sources (excluding those that are co-products of or brought in simultaneously with fiber raw materials), chemicals and fillers. Segments E and F refer to the emissions associated with post-production processes of marketing, distribution, and consumption. Finally, segment G, product disposal, encompasses landfill, disposal outside of landfills (e.g., decomposing in the atmosphere), incineration with or without energy recovery, and recycling. In the last two cases, recycling and energy with recovery of energy, some portion of this management must be considered as a part of the disposal emissions and another portion should be considered a reflection of the recycling or energy emissions. The arrows in between segments indicate transport that must be accounted for.

The present report addresses the production and disposal aspects of the footprint, as shown in Figure 2 below on two large virgin paper mills located in the Southern United States. The unshaded areas are the segments of the product life cycle that are not crucial to the analysis in this report, which is the emissions associated with production at the mills studied. A portion of segment D, secondary manufacture, is likely quite similar for alternative products and thus it is excluded in order to focus on the production segments most valuable to this analysis.[4]

Paper production segments relevant to this analysis



Below we describe the different areas of impact, the data used to estimate the impact and future research needs.

A. Direct Emissions – Paper Production
B. Indirect Emissions – Paper Production, Consumption and Disposal
C. Biomass / Forest Carbon Emissions

Direct Emissions – Paper Production

Segments A through D, from raw material resources through the production of the paper products, are direct emissions. This includes the collection of the raw materials (wood), transforming raw materials into pulp, and then from pulp into paper products. Also included should be the transport of the materials and wastes that occur during these processes and the embedded emissions for raw materials and energy inputs into the process.

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[4] We assume that secondary manufacture emissions are equivalent between recycled and virgin products.

Data for direct emissions are derived mainly from the Paper Task Force and the Paper Calculator, a project of the Environmental Defense Fund that compiled the most extensive public record of the environmental impacts of paper production in North America. To date, it remains the most reliable data and assessment tool for the paper sector.[5]

Indirect Emissions – Paper Production, Consumption and Disposal

Indirect emissions are generally those emissions that occur outside of the 'walls' of the production process. What are the emissions associated with the processing of primary fuels or other raw materials that did not take place at the site of production, such as the pulp and paper mill or forest? What are the emissions associated with product disposal and alternative prospects for these end-of-life impacts? What are the energy demands for different raw material inputs? This analysis includes as many of these impacts as possible, given the available data. The Paper Task Force analysis included some – but not all – indirect emissions in its analysis. Most of the larger impacts are included, such as chemical production.

Biomass / Forest Carbon Emissions

When a forest is harvested carbon is removed from the site. In papermaking, carbon is released during processing, some carbon goes into products and another portion is used for energy. That is, the carbon is transferred from one 'pool,' i.e., the forest, to other pools, products, landfills and the atmosphere. This analysis uses the IPCC's harvest emission equations to estimate these transfers.[4]

The IPCC equation for harvest emissions is as follows, taken from 2006 Guidelines for compiling national greenhouse gas inventories. IPCC methods are nationally scaled and primarily used for annual or periodic greenhouse gas inventories. They are not scaled for the product level and therefore we can extrapolate the impact at the product level by modifying the IPCC method.

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[5] In some cases additional data and methodologies were utilized as noted.

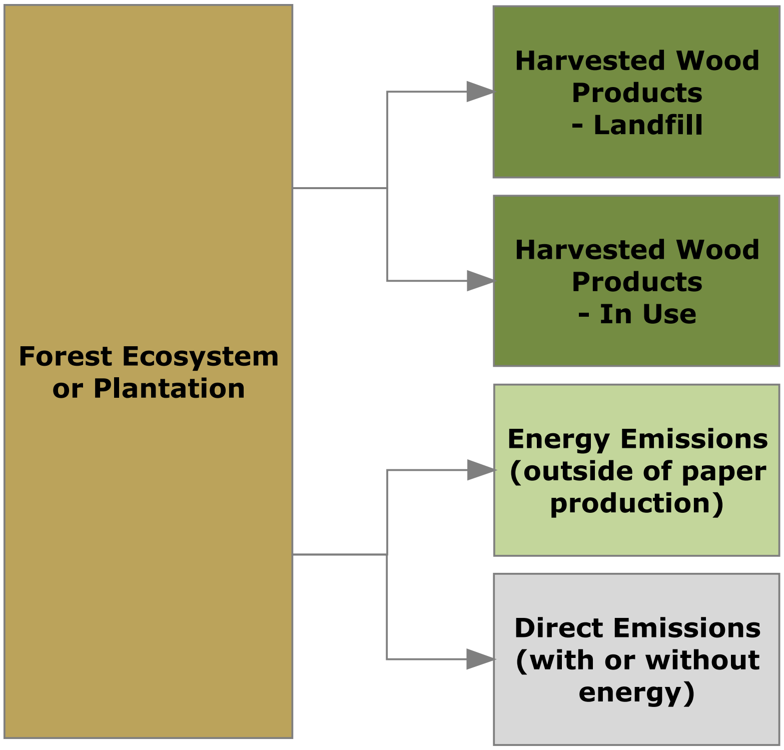
EQUATION 2.12
ANNUAL CARBON LOSS IN BIOMASS OF WOOD REMOVALS

$$L_{wood-removals} = \{H \bullet BCEF_R \bullet (1+R) \bullet CF\}$$

In essence, the equation explains that the emission is equal to the quantity of the removal, plus a factor for wood that will decay post harvest or is burned on site, plus a factor for carbon lost on site due to decay of material left behind (in many cases it is actually burned on site immediately following harvest for site preparation) and a factor for soil carbon losses.

Estimating forest carbon emissions presents a thorny *nominative* problem, i.e., how do we wish to define current emissions and/or sequestration from forest harvest for the production of wood products, paper products or energy. The problem is contrasted with emissions from fossil fuel sources, which have been clearly modelled. There are unresolved temporal and scalar issues with respect to forest carbon fluxes and forest management decisions. For example, how does one quantify carbon sequestered in forests 40, 100 or hundreds of years ago? What impact on the future should we consider for actions we take today?

Figure: Biomass Carbon Pools



Harvested Wood Products

In standard treatment under IPCC rules, allowance is made for what are termed *Harvested Wood Products (HWP)*. HWP is an estimate of the amount of carbon stored in wood products after removal from the forest ecosystem.[5] The US Forest Service explains the need for accounting for "When wood is harvested and removed from the forest, not all of the carbon flows immediately to the atmosphere. [...] Failing to account for carbon in wood products significantly overestimates emissions to the atmosphere in the year in which the harvest occurs."[6] For this analysis, we will assume HWP to be the total product.[6] The HWP calculation is only applied to the virgin content of the product and not to the recycled portion. Applying this factor to the recycled content would be double counting the storage of carbon first because it would already be accounted for in the virgin segment and second because HWP are an offset only to the carbon transfer from the forest pool to the product pool.

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[6] That is, HWP will be accounted for without decay and release to the atmosphere over time. This is the most favourable way to account for HWP, since in reality the products do decay over time and some analyses use the HWP only after 100 years after removal from the forest, as the USDA Forest Service report shows.

2. **Climate Impacts of the use of Biomass as energy;**
Isn't Tree Biomass Renewable and Therefore 'Carbon Neutral'?

Trees are in principle a renewable resource, although harvest practices can do long-term damage a forest ecosystem's resilience and the ability to store carbon.[7] However, the reason for performing a footprint analysis is to determine the impact of a product or service. Therefore, we must understand the impact on atmospheric levels of greenhouse gases due to the product: if we harvest the forest, what is the impact? Our other choice is to not to harvest the forest, to harvest less of the forest, or indeed, if we decide the price is good enough, then to harvest more forest, perhaps using the extra trees as an energy source. Our purpose is to understand the opportunity costs of our decisions, for which there is no explicit price or market. In the case of carbon footprinting, we hope to reduce our impact on the climate, and each time we take trees out of the forest and release the stored carbon into the atmosphere, there is an emission. Thus, although the level of carbon in the forests over the long term and across the landscape *might* be roughly in stasis, harvest emissions are not neutral to the atmosphere: those harvest emissions mean more carbon dioxide in the sky and this *must* be accounted for.

There are other reasons why harvest emissions must be accounted as well. Harvest often *slows the rate* of carbon sequestration in forests. Many intermediate aged-forests (between, say forty and eighty years) are the strongest growers and absorbers of carbon of any age class in many ecosystem types. Many young forests or plantations with strong early, post-disturbance growth require fertilizers and chemicals to achieve that growth with their own greenhouse gas emissions that would need to be accounted for. Thus, we not only *release* carbon dioxide that was stored in trees, but the ability to absorb carbon dioxide is reduced.[8] Newly harvested areas, in addition, are subject to decay of the material left in the forest for a considerable period of time – up to twenty years – until the very small trees of the newly growing forest are able to absorb more carbon dioxide than is being released.[9]

Direct Biomass Emissions for the Mills

Pulp and paper mills, like those analyzed for this report use large amounts of timber to create their products. An important and little know factor about pulp and paper mills is that only a small minority portion of the timber consumed at the facility actually becomes part of the final paper product. The majority of the timber's carbon content is released to the atmosphere both as energy when the material is used as fuel at the mill and lost through the production process. According to the Paper Calculator, the mills' average requirements for timber (using North American averages) range between 3.63 and 4.54 metric tonnes per tonne of final product.[10] The average carbon content of trees is approximately 0.5, or half.[11] Measured in carbon dioxide equivalent (CO_2e), this means the mills consume between 6.7 and 8.3 tonnes of carbon dioxide equivalent in trees per tonne of product. After subtracting for Harvested Wood Products (as discussed above, this is a very generous calculation of the storage over time), the final biomass emission for such a mill can be estimated, as shown in the chart below. All of the data points used and derived are given in a complete chart in the appendix to the report.

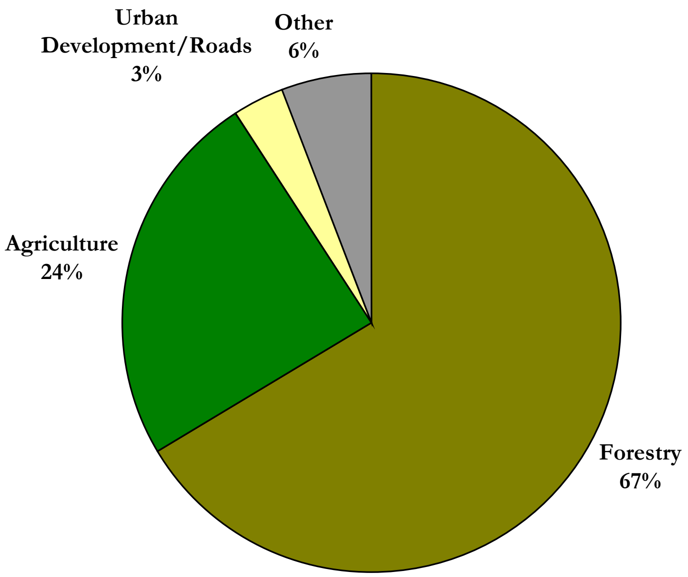
Chart: Direct Biomass Emissions

Mill	Product	Direct Carbon Biomass Emission	Direct Carbon Biomass Emission
		metric tonnes CO2e	metric tonnes CO2e / tonne of product
Riegelwood, NC	folding boxboard	487,102	6.9
	food service board	673,147	5.2
	paperboard	1,282,967	6.9
Augusta, GA	boxboard	4,365,780	6.9

Direct Impacts on Forest Ecosystems

Historically, the states and region where these mills are located and where the source their wood fiber were heavily forested. Forests have been converted to a number of other land uses, such as agriculture and urban development. In addition, forest carbon mass has been substantially reduced through management decisions, such as regular, short-term harvest and to plantation forestry that has come at the expense of natural forests. According to the Southern Forest Resource Assessment,[12] before European immigration to the region, Georgia, North Carolina, South Carolina and Virginia had 35,700, 29,630, 17,570 and 24,480 thousand forested acres each respectively. Today forests and plantations cover 24,413, 19,278, 12,646, and 16,027. This is a reduction of about one third of the total forested area. As data from the same study further show, pine plantations have come at the expense of natural forests much of the time in recent years and more rarely from abandoned agricultural land. In Virginia, for example, of the 1,275,000 acres of planted pine, 115,000 acres were previously natural pine, 41,000 were previously natural oak-pine, 285,000 came at the expense of lowland and upland hardwood ecosystems while only 43,000 acres were previously 'nonforest.' Not all states have this high a rate of conversion from natural forest to pine plantations, but all have a majority of pine plantations coming at the expense of natural forests and a minority from agricultural or other nonforest land.

Share of land use by sector in the Waccamaw region



The forestry sector has a major impact on the Mid-Atlantic Coastal ecosystem, perhaps the largest impact of any economic activity in the region. Paper makes up the lion's share of that impact. According to the USDA Forest Service, overall in the South in 2001, pulpwood made up around 42 percent of all harvests and saw logs an additional 41 percent, a large portion of the saw logs make their way into paper as well.[13] In the Waccamaw region of southeastern North Carolina, forestry is by far the dominant land use, as the figure above shows.[14] Indeed, forestry may be the single-most important deciding factor in how much carbon is kept out of the atmosphere in the region with respect to forest carbon flux to the atmosphere.

Alternative Scenarios for Forest Biomass

To demonstrate that our estimate for carbon loss due to harvest is a conservative one, we compare a set of harvest versus no-harvest scenarios. For key ecosystem types in the region, we compare the carbon storage over time under harvest and no-harvest scenarios. For each scenario, we can develop an average storage amount for a one-hundred-year period and also note the end point results as well as compare average storage over 100 years for the rotation forests to the end result of the no-harvest scenario. All of these comparisons provide an alternative sensitivity analysis. A sensitivity analysis is a comparison of one result using one methodology with results using different methodologies or assumptions to ensure the finding is robust and appropriate to the analysis. For additional sensitivity analysis, we will also examine a forty year time horizon that coincides with the year 2050 as of the publication of this report, a year around which many governments are focusing planning efforts for reducing greenhouse gas emissions. A conservative estimate for the harvest emission will be one where the average storage over time is less than the harvest emission estimate. We will begin using USDA Forest Service data that has compiled carbon storage rates for a variety of ecosystem types. According to the USDA Forest Service,[15] the following are the most common ecosystem types in the region:

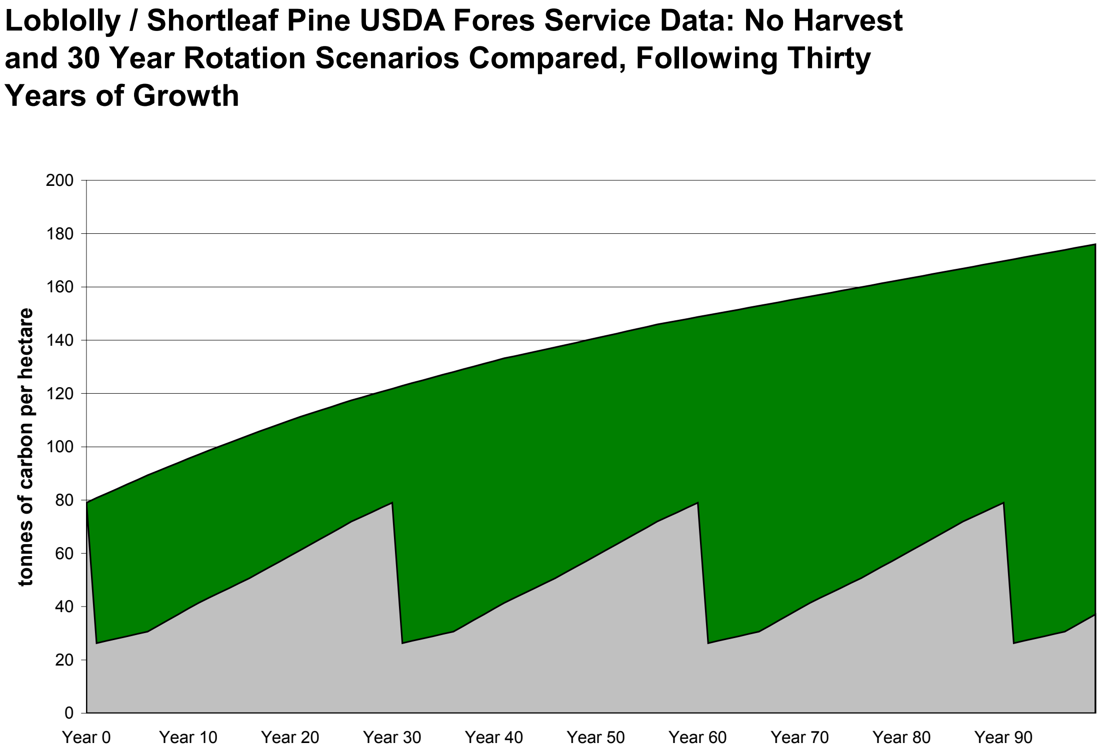
- Longleaf/Slash
- Loblolly/Shortleaf
- Oak/Pine
- Oak/Hickory
- Oak/Gum/Cypress
- Elm/Ash/Cottonwood
- Maple/Beech/Birch
- Other Hardwood

Recent findings of direct measurement in forest ecosystems have demonstrated that early growth in re-established stands is much slower than in intermediate-aged growth. For example, one recent study found growth of hardwood forests to be slow at year 6 since disturbance to be only 0.53 tonnes of carbon sequestered per year per hectare, while maximum growth rates (i.e., carbon accumulation rates) were attained between years 24 (0.74 tonnes C / ha / yr) and 50 (0.95 tonnes C / ha / yr).[16] Even at year 68 since harvest, growth was much stronger than in the early stage, at 0.83 tonnes C / ha / yr. Thus, given these measurements, all replacements of older stands with younger stands not only removed the carbon from the site, but also greatly reduced the carbon sequestration potential of the site for several decades. Using this data, we would find our estimates to be even more conservative than in the above scenarios.

Loblolly and Shortleaf Pine ecosystems are some of the most common types in the Mid-Atlantic region. In order to understand whether the IPCC equation would derive a conservative estimate for the emission, we start at a reasonable decision-point: following forty years of growth, we examine the no-harvest and harvest scenarios over 100 years and compare the average storage and the end result. Comparing the harvest and no-harvest scenarios over 100 years, we find that the no-harvest scenario would store an average 136.1 tonnes of carbon per hectare over 100 years, although at the end of the period storage would climb to 155.7 tonnes C/ha. Regular thirty-year harvests in the same ecosystem type yield an average 49.7 tonnes C/ha, with a range of 26.3 and 79 tonnes C/ha. The original harvest emission in this scenario, the amount of wood the harvest would yield, would be calculated at less than 58.2 tonnes C – the live tree portion of the carbon storage in the ecosystem at the time of harvest. The average carbon storage difference between the two scenarios over the period is 86.4 tonnes C/ha, while the difference between the average storage in the harvest scenario and the final storage value after 100 years in the no-harvest scenario is nearly 139 tonnes C/ha. Judging the differentials over a forty year time horizon – chosen because of the prevalence of 2050 as an important time-frame for reducing GHGs in the atmosphere, we find a no harvest surplus (or a harvest scenario deficit) of 60.9 tonnes C/ha. This analysis demonstrates that the IPCC equation does indeed produce a conservative estimate over the two time horizons.

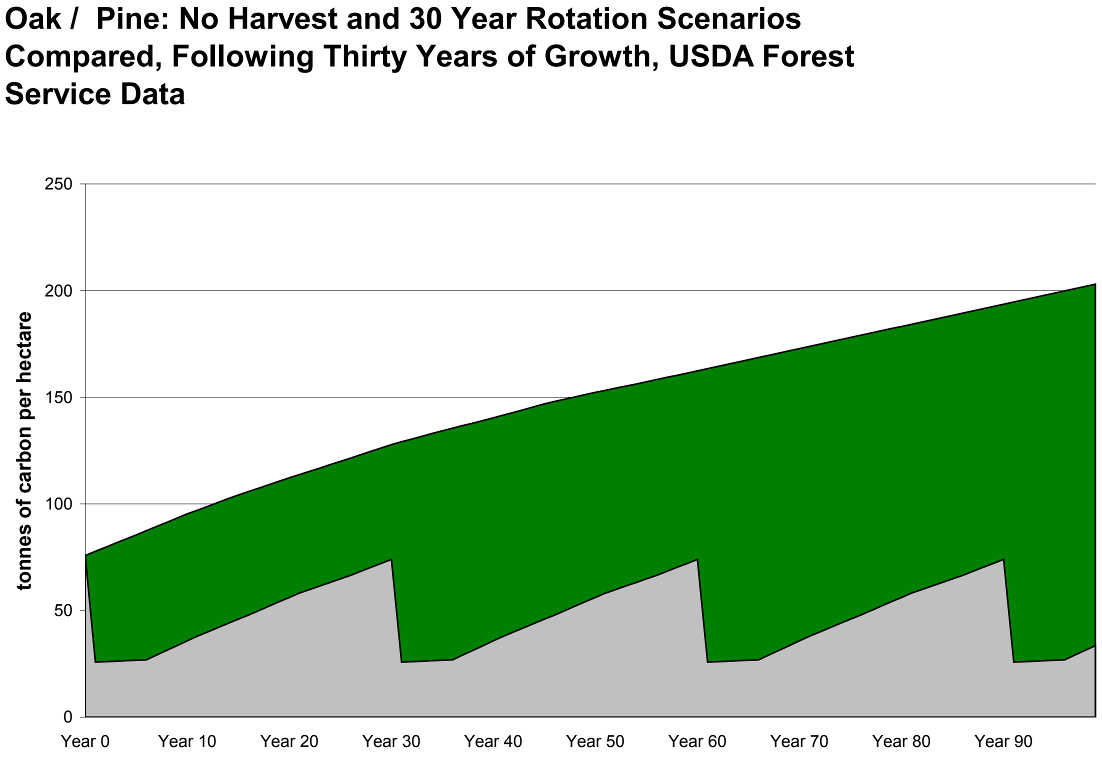
We carried out the same analysis for several other ecosystem types and under different rotation ages. These include mixed softwood and hardwood ecosystems (Oak / Pine) and hardwood dominant ecosystems (Oak / Hickory). Both were analyzed for thirty-year and forty-year rotations. In all circumstances under the 100 year time horizon, the IPCC equation produces a conservative estimate of the GHG balance between forest ecosystems and the atmosphere. In all circumstances, the end of the 100 year scenarios demonstrates a highly conservative estimate of emission. The same is also true of the ecosystem carbon storage values by 2050, the 40 year time horizon except for one scenario, the Oak / Pine ecosystem under forty year rotations.

In this scenario, storage in the Oak /Pine no harvest forest would contain 151.22 tonnes C/ha, the 40 year rotation forest 91.38 tonnes C/ha. The no-harvest surplus in this scenario is 59.84 tonnes C/ha, while the harvest estimate would be 73.4 tonnes C/ha. The results of this analysis are demonstrated in the following charts as well as the table below. This last finding indicates that there may be some extended rotation periods and ecosystem types may require a lower emissions estimate due to better retention of carbon across the landscape over time. That is, if we extend rotations, the full impact of harvest over time may be less than the IPCC estimate would produce over time and these exceptional circumstances would require a co-efficient for reducing the emissions estimate due to extended rotations.



Loblolly / Shortleaf Pine USDA Fores Service Data: No Harvest and 30 Year Rotation Scenarios Compared, Following Thirty Years of Growth

Figure: Loblolly / shortleaf pine accumulated carbon storage using USDA Forest Service data. The green area represents the ‘no harvest’ option, i.e., leaving the forest unharvested over a period of 100 years, compared with the grey area that represents the same forest area regularly harvested and the resulting carbon storage in that stand.



Oak / Pine: No Harvest and 30 Year Rotation Scenarios Compared, Following Thirty Years of Growth, USDA Forest Service Data

Figure: Oak / pine accumulated carbon storage using USDA Forest Service data. The green area represents the 'no harvest' option, i.e., leaving the forest unharvested over a period of 100 years, compared with the grey area that represents the same forest area regularly harvested and the resulting carbon storage in that stand.

These above figures, and the additional scenarios detailed in the tables in the appendices demonstrate that the methodology adopted in this report is a conservative one both at the moment of harvest as well as over time. The harvest scenario in almost every case (the single case is where rotations are extended, further demonstrating that extended rotations can help to store additional carbon) stores less carbon on the landscape than the no-harvest scenario.

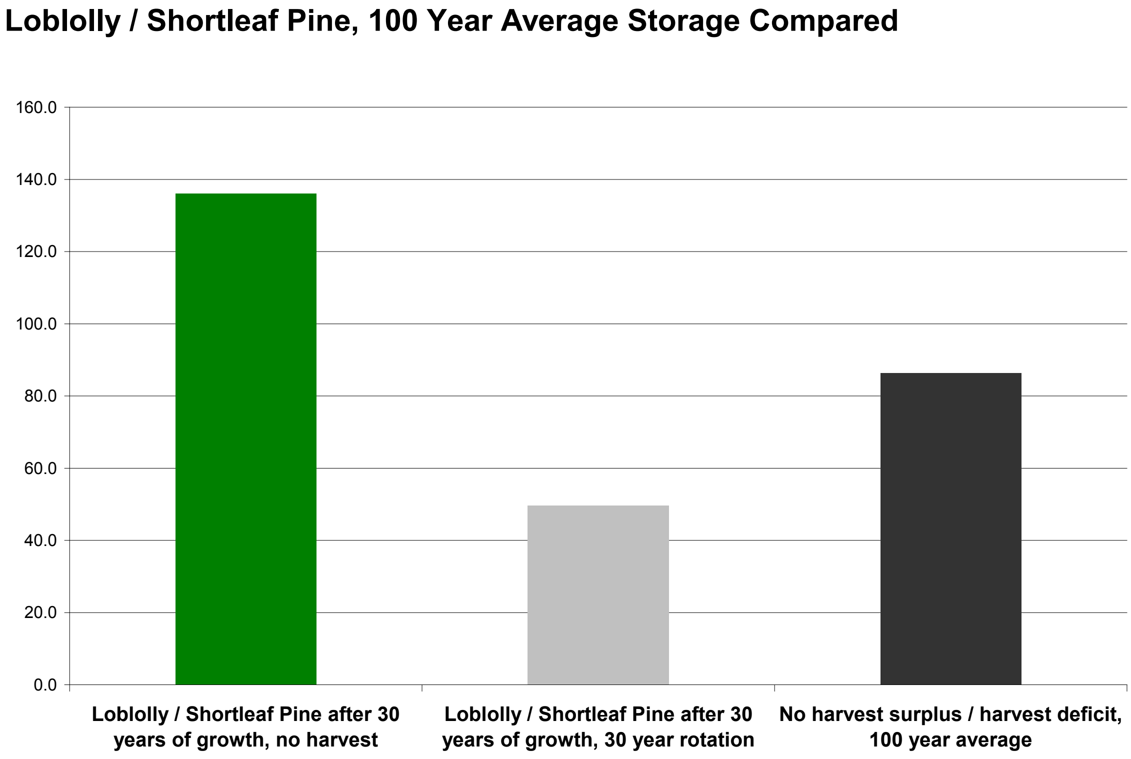


Figure: In loblolly / shortleaf pine forest ecosystems, average storage under harvest and no-harvest scenarios over a 100-year period. Carbon stored on the landscape, and thus for the most part kept out of the atmosphere, is more than twice the harvest scenario. The landscape carbon storage deficit, on average, is twice the mass of carbon stored in harvested forests over a 100-year period for these softwood-dominated ecosystems. Some of the carbon deficit will be stored in products over time, but for paper products the amount stored is small.

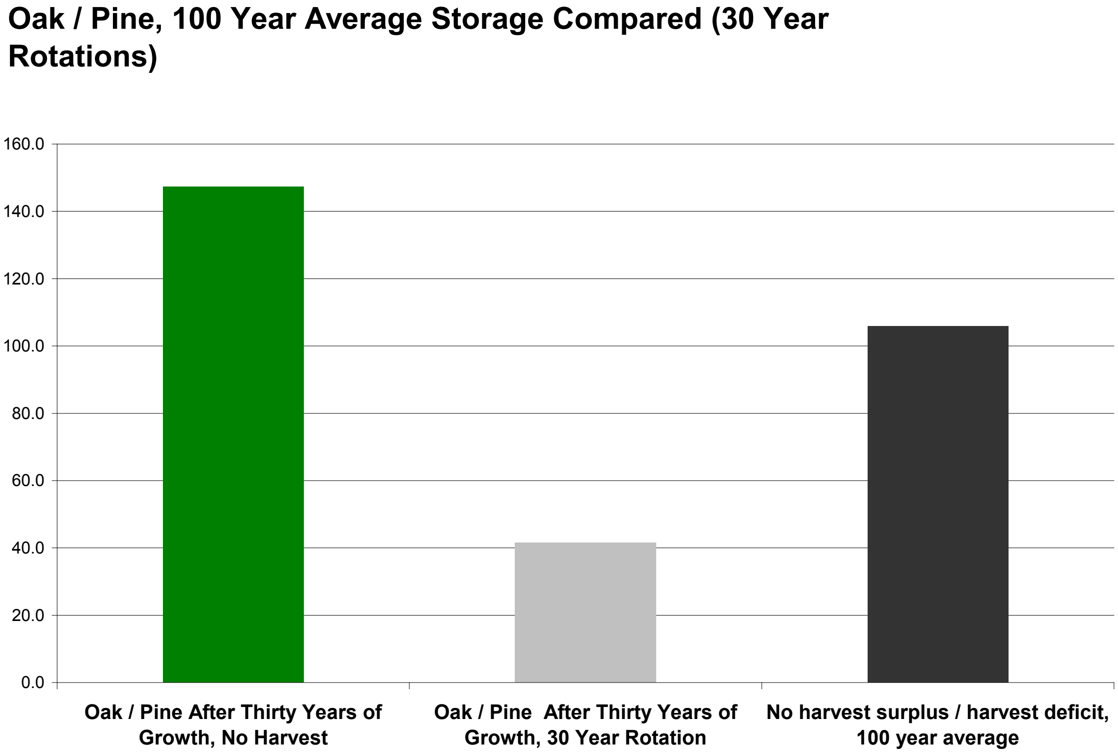
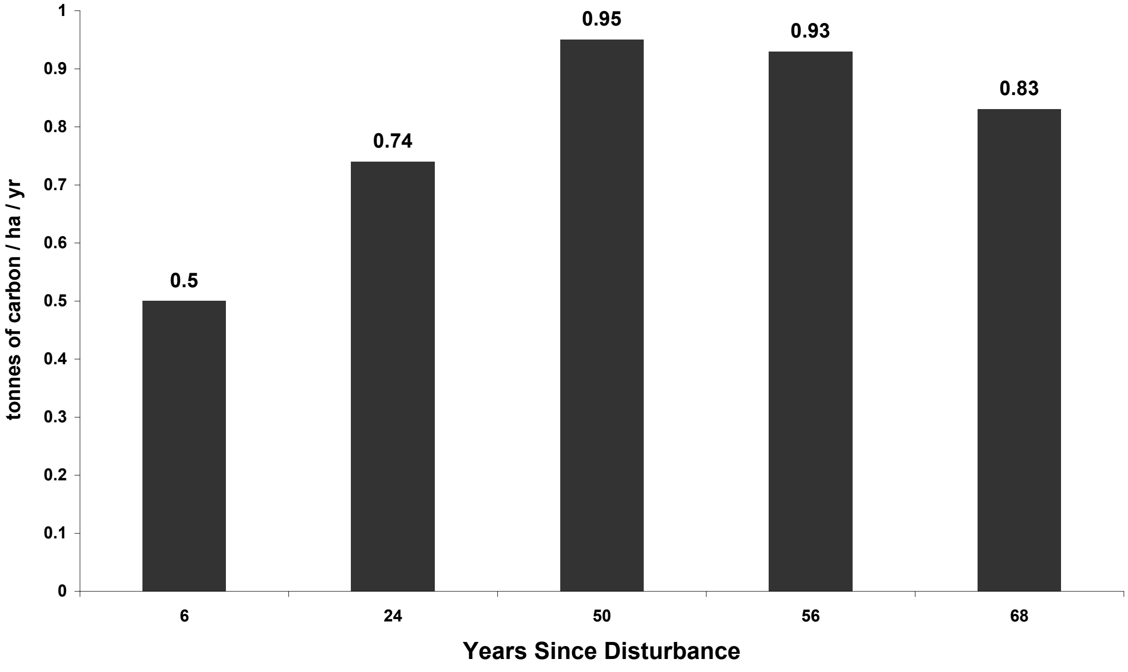


Figure: Mixed oak / pine landscape carbon storage averages compared. Carbon stored in unharvested forests over a 100-year period on average in these mixed hardwood/softwood ecosystems is over three times storage in harvested forests.

Summary Table: Ecosystem types, carbon storage and management activity	**Value, tonnes carbon / ha**
Loblolly / Shortleaf Pine after 30 years of growth, no harvest	136.1
Loblolly / Shortleaf Pine after 30 years of growth, 30 year rotation	49.7
No harvest surplus / harvest deficit, 100 year average	86.4
Estimated transfer to non-forest pools	58.2
Oak / Pine After Thirty Years of Growth, No Harvest	147.4
Oak / Pine After Thirty Years of Growth, 30 Year Rotation	41.5
No harvest surplus / harvest deficit, 100 year average	105.9
Estimated transfer to non-forest pools	55.4
Oak / Hickory After Thirty Years of Growth, No Harvest	156.2
Oak / Hickory After Thirty Years of Growth, 30 Year Rotation	41.5
No harvest surplus / harvest deficit, 100 year average	114.7
Estimated transfer to non-forest pools	57.5

Oak / Pine After Forty Years of Growth, No Harvest	157.2
Oak / Pine After Forty Years of Growth, 40 Year Rotation	53.2
No harvest surplus / harvest deficit, 100 year average	104.0
Estimated transfer to non-forest pools	73.4
Oak / Hickory After Forty Years of Growth, No Harvest	168.4
Oak / Hickory After Forty Years of Growth, 40 Year Rotation	49.2
No harvest surplus / harvest deficit, 100 year average	119.2
Estimated transfer to non-forest pools	76.2
Oak / Hickory After Forty Years of Growth, No Harvest	168.4
Oak / Hickory After Forty Years of Growth, Harvest and Replacement with Loblolly / Slash Pine	49.3
No harvest surplus / harvest deficit, 100 year average	119.1
Estimated transfer to non-forest pools	57.5



Carbon Accumulation in Forests at Different Ages Since Distrubance (Gough et al., 2007)

On-site Losses in the Forest Ecosystem

In addition to the wood taken from the site and used at the mill, there are two sources of on-site emissions. They are the material left on the ground after harvest, called slash, including "tree tops, branches, twigs, foliage, [and] sometimes stumps,"[17] and soil carbon losses due to exposure. Slash can be left to decay over time or it can be burned during site preparation. In order to derive a single number for the emissions that occur over time, we assume that these losses occur in the same year as harvest, as IPCC rules allow.

USDA Forest Service charts assume zero soil carbon losses after harvest. This report will adopt that assumption for those forests where there is no manipulation of the soils. However, there is a great deal of ditching and draining occurring that does expose soils and does result in sizable carbon emissions from them. There a still many scientific unknowns about the relationship between forestry and soil carbon losses.

Climate Impacts of the Mills

We review these two large paper packaging mills of great significance to the Southern Atlantic Coastal Forest ecoregion. The mills' sourcing region extends along the coast from northern Virginia, through eastern North Carolina to northern Georgia and South Carolina. All of these mills are integrated paper and packaging mills, producing both packaging papers and the pulp used to make this paper.

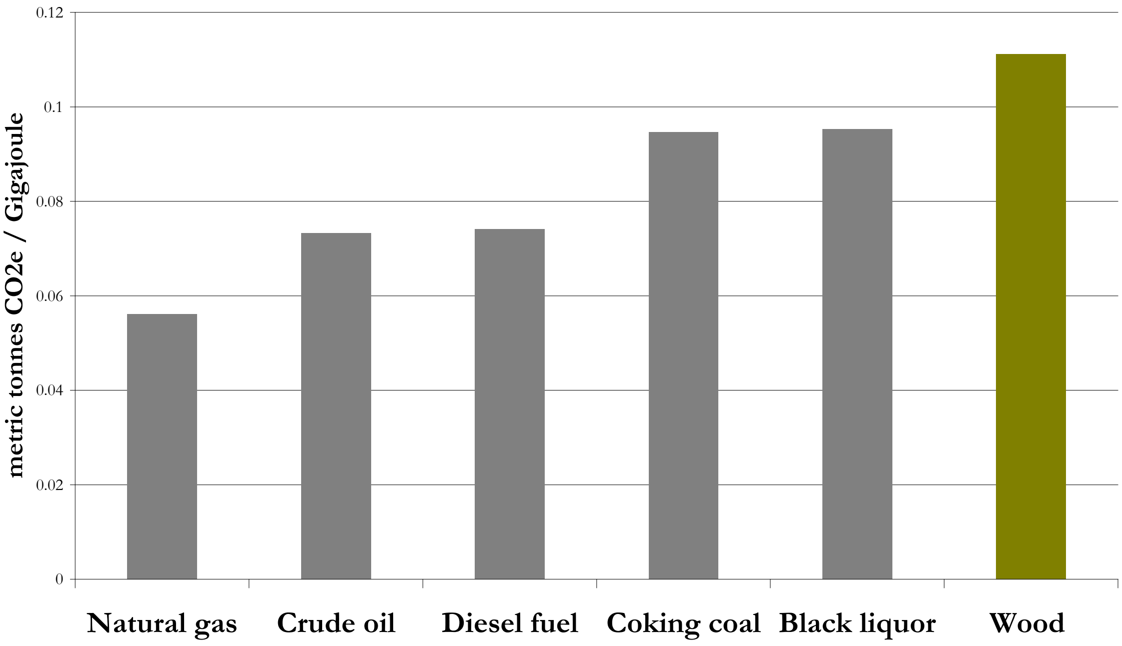
Company	Mill, State	Products	Virgin Production (capacity in metric tonnes)	Recycled Production (capacity in metric tonnes)
International Paper	Riegelwood, NC	folding boxboard	71,054	
		food service board	129,683	
		paperboard	187,148	
International Paper	Augusta, GA	boxboard	636,840	

The numbers in the figure above indicate the total packaging paper manufactured at the mill. Total paper production includes pulp (around 90%, on average, of the total for these grades) and fillers. The pulp portion is primarily made from semi-chemical and chemical pulps. Chemical pulps require the greatest amount of wood demand of any pulp type per unit of output.

As a matter of public policy, large incentives have recently been granted for the use of biomass as an energy source, in order to reduce the amount of fossil fuels consumed. As a result many mills are increasing the numbers of trees they burn. Accordingly, this results in an increase in the total area of forests that must be disturbed and the carbon released to the atmosphere. For example, a large competitor in the cut sheet paper marketplace, Domtar states explicitly that a central part of their energy strategy will be to reduce their reliance on fossil fuels by using more wood. But the carbon released to the atmosphere is the same, and potentially greater, the key factor in climate change.[18]

While it may be a good thing, absent any other consideration, to reduce fossil fuel consumption, the total amount of greenhouse gases released by the production of energy is not substantially reduced, and may be greater, in addition to the impact on the forest ecosystem. As the figure below demonstrates, in the short and medium terms at a minimum (over the next decades), increasing biomass consumption and the use of black liquor and wood as a fuel may increase carbon dioxide and other greenhouse gases in the atmosphere, rather than reduce them.[7]

Greenhouse gas emissions per energy output



Source: IPCC coefficients, 2006 Guidelines for National Greenhouse Gas Reporting

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[7] It should be noted that embedded energy requirements for the production of these different energy types would alter the relative total emissions from these sources.

Based on averages developed by the Paper Task Force project, the mills in question consumed slightly less than 5.4 million metric tonnes of trees. Much of that goes into energy production for the mill, with a minority portion actually becoming paper. Per tonne of product, direct biomass emissions range from zero, for recycled products, to 6.9 tonnes carbon dioxide equivalent. The emissions are summarized in the table below.

In addition, there are emissions associated with the production of chemicals and fillers, the pulping and paper production process, releases from fossil fuels and the rest of the process as described in the methodology section. These non-biomass emissions are estimated at up to 3.93 tonnes carbon dioxide equivalent for the food service board produced at the Riegelwood Mill.

Summary of Biomass / Forest Carbon Emissions

Mill	**Product**	**Direct Carbon Biomass Emission**	**Direct Carbon Biomass Emission**
		metric tonnes CO2e	**metric tonnes CO2e / tonne of product**
Riegelwood	folding boxboard	487,102	6.9
	food service board	673,147	5.2
	paperboard	1,282,967	6.9
Augusta	boxboard	4,365,780	6.9
Total Biomass Emission		**6,808996**	

Summary of Total Emissions

Mill	Products	Paper Production	Direct and Indirect Manufacturing and Waste Disposal Emissions*	Direct Biomass/ Forest Emission	Total Emissions	Emission Per Tonne of Product
		(capacity in metric tonnes)	(metric tonnes CO2e)	(metric tonnes CO2e)	(metric tonnes CO2e)	(metric tonnes CO2e / tonne of product)
Riegelwood	folding boxboard	71,054	215,679	487,102	702,781	9.9
	food service board	129,683	462,643	673,147	1,135,790	8.8
	paperboard	187,148	568,072	1,282,967	1,851,040	9.9
Augusta	boxboard	636,840	1,933,081	4,365,780	6,298,861	9.9

Conclusion and Alternatives

Paper production uses vast amounts of energy and resources. And the production of paper from virgin sources is even more energy intensive. A study done for the U.S. Energy Information Agency estimated the pulping energy requirements as follows:

	Virgin chemical pulp	**Deinked recycled pulp**
	10^6 BTU / ton of pulp	**10^6 BTU / ton of pulp**
Wood preparation		
Debarking	0.1	0
Chipping and conveying	0.35	0
Pulping		
Kraft process	2.6	0
Recycled deinking	0	1.3
Kraft chemical recovery process		
Evaporation	3.86	0
Recovery boiler	1.13	0
Calcining	2.03	0
Pulp bleaching	2.3	0
Paper production	6.26	6.26
Totals	**18.63**	**7.56**

Chemical virgin production of paper uses nearly two and a half times the energy requirements of recycled paper. The majority of that energy comes from the burning of wood. Strategies to reduce virgin production and increase the use of recycled pulp in our total paper production are necessary to any climate change mitigation strategy for the overall economy. The greenhouse gas emissions from just these two alone were responsible for emitting over 7,507,000 tons of carbon in a single year. According to the EPA, that's the equivalent of the emissions from 1,301,911 passenger vehicles or the annual emissions from nearly two coal fired power plants.

Improved forest management can have a positive impact on the climate. Good forest management, which currently can only be effectively demonstrated by FSC certification, helps to protect non-target portions of the forest biomass (e.g., protecting dead wood or by a more judicious selection of trees for harvest), promotes longer rotations, and promotes the protection of those portions of stands and landscapes where other values should be considered, such as protecting high biodiversity areas or riparian zones. To date, few studies have been quantified the climate benefits of good forestry on the ground that can be used in this study. This is an area that requires much more intensive study as the issue of climate change becomes more and more important and timely.

The average American citizen was responsible for 23.5 tonnes of greenhouse gas emissions (in carbon dioxide equivalents).[19] This would include all of the industry, transport and other activities excluding land-use, land-use change and forestry. The biomass emissions from these two mills alone – forest biomass taken from the ecosystems and released to the atmosphere during the production of the product – are equivalent to the fossil fuel emissions of more than 450,000 average Americans.

Table: Potential for GHG Emissions Savings from Conversion to Recycled Content

Mill	Company	Product	Estimated emissions per tonne of product	Estimated average emissions for 100% recycled alternatives	Total savings if 100% recycled
			metric tonnes CO2e per tonne of product	**metric tonnes CO2e per tonne of product**	**metric tonnes CO2e**
Riegelwood	**International Paper**	folding boxboard	9.9	1.8	571,800
		food service board	8.8	1.9	893,790
		paperboard	9.9	1.8	1,506,051
Augusta	**International Paper**	boxboard	9.9	1.8	5,124,909

The production of virgin paper products at the mills for which emissions are estimated in this report have very serious climate impacts. Virgin paper production requires very high amounts of energy, a portion of which is supplied by fossil fuel production, a small portion of which is provided by non-fossil, truly renewable energy, and a large portion of which is supplied by depleting forests for energy. The most effective mean of reducing this impact is to use less, but the use of recycled content also has very great advantages for the reduction of fossil fuel use and for allowing forests to maintain and increase their carbon rather than emitting that carbon to the atmosphere.

Recommendations for Reducing the Climate Impact of Your Paper Consumption

1. Find ways to reduce paper use.
- Less paper use means less energy use, less pressure on forests, more opportunity for forests to recover their historic carbon levels.

2. Seek out recycled paper wherever possible.
- Recycled paper means less chemicals, less energy, less fossil fuels and no new trees cut down for paper, all reducing your climate impact.

3. For virgin content, specify FSC, Forest Stewardship Council
- FSC certification requires a demonstration of good forestry practices, which can mean longer rotations, smaller cut blocks, reduced impact on non-harvested trees, and protection of forests with special ecological and social values. This lower impact in the forests means less impact on the climate.

4. Don’t accept the false claims of the paper industry of ‘carbon neutral’ paper or ‘carbon neutral’ biomass.
- All products require inputs and energy and for virgin paper fiber there is a big opportunity cost of using forests for energy and paper instead of keeping that carbon out of the atmosphere and in the trees.

Mill	Product	Production, Virgin Content Only	Total Production, Virgin Content and Recycled Content	Total Wood Input	Total Wood Input Carbon Content	Total Product Carbon Content	Direct Carbon Biomass Emission	Direct Carbon Biomass Emission
		metric tonnes	metric tonnes	metric tonnes	metric tonnes CO2e	metric tonnes CO2e	metric tonnes CO2e	metric tonnes CO2e / tonne of product
Riegelwood	folding boxboard	71,054	71,054	322,294	591,409	104,307	487,102	6.9
	food service board	129,683	129,683	470,584	863,522	190,375	673,147	5.2
	paperboard	187,148	187,148	848,883	1,557,700	274,733	1,282,967	6.9
Augusta	boxboard	636,840	636,840	2,888,644	5,300,662	934,882	4,365,780	6.9

Mill	**Products**	Paper Production (capacity in metric tonnes)	Direct and Indirect Manufacturing and Waste Disposal Emissions* (metric tonnes CO2e)	Direct Biomass Emission (metric tonnes CO2e)	Indirect Forest Emissions (metric tonnes CO2e)	Total Emissions (metric tonnes CO2e)	Emission Per Tonne of Product (metric tonnes CO2e / tonne of product)
Riegelwood	folding boxboard	71,054	215,679	487,102		702,781	9.9
	food service board	129,683	462,643	673,147		1,135,790	8.8
	paperboard	187,148	568,072	1,282,967		1,851,040	9.9
Augusta	boxboard	636,840	1,933,081	4,365,780		6,298,861	9.9

(Endnotes)

[1] Righelato, Renton and Dominick V. Spracklen. Carbon Mitigation by Biofuels or by Saving and Restoring Forests? Science, Volume 317. 17 August 2007.

[2] Timothy D. Searchinger, et al. "Fixing A Critical Climate Accounting Error." *Science* Vol. 326. 23 October 2009.

[3] Houghton, R.A. "The annual net flux of carbon to the atmosphere from changes in land use 1850 – 1990." *Tellus* 51B, 1999. Rhemtulla, Jeanine M. et al. "Historical forest baselines reveal potential for continued carbon sequestration." Proceedings of the National Academy of Scientists. www.pnas.org/cgi/doi/10.1073/pnas.0810076106.

[4] The carbon accumulation rates in the USDA Forest Service data is much more generous in their carbon accumulation than recent studies have indicated may be the case and also show much lower rates of carbon loss onsite due to post-harvest decay.

[5] IPCC. 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

[6] Smith, James E., Linda S. Heath, Kenneth E. Skog, Richard A. Birdsey. 'Methods for Calculating Forest Ecosystem and Harvested Carbon with Standard Estimates for Forest Types of the United States.' United States Department of Agriculture Forest Service. Northeastern Research Station. General Technical Report NE-343.

[7] Gough, Christopher M., et alia. 'Controls on Annual Forest Carbon Storage: Lessons from the Past and Predications for the Future.' *Bioscience*. Vol. 58. No. 7. July / August 2008.

[8] Gough, Christopher M., et alia. 'The legacy of harvest and fire on ecosystem carbon storage in a north temperate forest.' Global Change Biology (2007) 13, 1935–1949, doi: 10.1111/j.1365-2486.2007.01406.x

[9] Law, Beverly E. "Eddy-Flux, Ecophysiological and Carbon Storage Measurements at Metolius AmeriFlux Sites, Oregon." http://mercury.ornl.gov/metadata/ornldaac/xml/landval/record45.xml

[10] Paper Task Force. White Paper 3. 'Lifecycle Environmental Comparison: Virgin Paper and Recycled Paper Options.' Originally Published on December 19, 1995. Data in Sections II and IV and Appendices C and D Updated in February 2002.

[11] International Institute for Applied Systems Analysis. 'Austrian Carbon Database: Production and Waste. Material Flow Based Carbon Accounting for 1990.' 27 July 2001.

[12] USDA Forest Service. www.srs.fs.usda.gov/sustain/

[13] USDA Forest Service Southern Research Station. *Southern Forest Resource Assessment Update 2007.*

[14] Riggs, Stanley R. et al. *The Waccamaw Drainage System: Geology and Dynamics of a Coastal Wetland, Southeastern North Carolina.* North Carolina Department of Environment and Natural Resources. September 2000.

[15] Samuel Lambert, USDA Forest Service, *pers.comm.*

[16] Gough, Christopher M., et alia. Global Change Biology (2007) 13, 1935–1949, doi: 10.1111/j.1365-2486.2007.01406.x

[17] IPCC. 2006 IPCC Guidelines for National Greenhouse Gas Inventories, p. 4.13.

[18] Domtar, Inc. Greenhouse Gas Action Plan. 2001. www.ghgregistries.ca/registry/out/C0499-DOMTAR02-PDF.PDF

[19] World Resources Institute Climate Analysis Indicators Tool.

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