Paper Vapour

A discussion paper commissioned by the European Environmental Paper Network's Paper Efficiency Project

'Paper Vapour' – the climate impact of paper consumption

The European Environmental Paper Network (EEPN) presents here preliminary findings that give a strong indication of the climate impacts of paper use and the need to reduce carbon emissions through paper efficiency. The huge energy requirements for paper production raises important questions about biomass related issues. There is a general agreement within the EEPN that biomass, i.e., fibre from wood, is not per se carbon neutral. However, more debate and research is needed on which factors to include to account for biomass carbon emissions and the need to differentiate between positive and negative aspects of biomass use. The analysis here suggests that half of the emissions from paper may result from biomass emissions, and that there is an urgent need, therefore, for more investigation and discussion. This paper is not intended as a final account of the topic but rather offered to invite debate with all interested stakeholders. Please send your feedback to this paper to hag@environmentalpaper.eu by 31 August 2013.

Introduction

Paper brings great benefits to society through education, hygiene, art and literature. It is a valuable resource yet, like many other commodities, it is overused and frequently misused, particularly in industrialised countries. In order to reduce the negative impacts that the life cycle of paper has on the environment, it is imperative that society uses paper more efficiently and ensures it comes from responsible sources. In particular, the life cycle of paper causes such significant carbon emissions that paper efficiency should be a central part of all organisations' climate change policies and action plans.

New analysis of the carbon footprint of the global paper industry[1], commissioned by the European Environmental Paper Network (EEPN), has found that previous research omitted key stages of paper's life cycle and, thereby, under-

[1] The analysis was carried out as part of the EEPN's Shrink Paper project, which aims to encourage paper efficiency across the UK.

estimated its impact on the global climate. This analysis is based on a review of more than 20 carbon footprint studies[2], covering dozens of paper products and paper production systems. The results of impacts throughout the life cycle of paper, including the impact in the forest, were combined. It suggests that, even though it comes from a renewable source, paper has a greater impact on the climate than most other industries. Its production cycle – from the forest to the mill and secondary manufacturing, to consumers through to recycling or disposal – emits a considerable quantity of greenhouse gases (GHGs) and has a significant impact on the carbon stored in forests.

In principle, materials made from renewable sources, such as wood, should play an important role in a low carbon economy. This research, however, highlights that from a climate perspective, paper should be more highly valued as a resource and the ways in which it is commonly used should be reassessed. Whilst a book has a long shelf life and stores carbon for many years, many short lifecycle paper products intensify the carbon impact of paper.

To highlight the underestimated climate impact of wasteful paper use, the EEPN calls these emissions 'paper vapour'. It recommends that an efficient way for society to help mitigate climate change is to reduce low utility uses of paper, such as 'throw away' and 'disposable' products.

Summary of findings

This research, commissioned by the EEPN, has attempted to calculate the climate impacts of paper more comprehensively than ever before. A number of questions have yet to be answered, such as carbon calculations related to land-use change, types of biomass used, types of forest management, timelines, regional factors etc. However, the following preliminary conclusions can be drawn:

- The analysis suggests that paper has a very significant impact on the climate and that its 'vapour trail' accounts for the equivalent of more than 7% of global GHG emissions, which is higher than aviation emissions[3]. According to these latest calculations, paper's impact is greater than the following industries: waste and landfilling; chemical production; oil and gas production; fuel and power for commercial buildings; and steel, aluminium and iron production combined;

- This analysis estimates that on average at least 7kg of 'paper vapour' is emitted for every kg of paper produced. Further analysis and more data would add accuracy to, and confidence in, the estimate;

[2] All studies used are listed at the end of this document. LCAs, carbon footprints and other studies reviewed, but from which data could not be used, are not listed.

[3] See footnote on aviation emissions in Table 2 below.

- This analysis further indicates that over 50% of the carbon footprint[4] of paper comes from direct and equivalent biomass emissions combined. Differences in forest management practices and ecosystem types will cause this estimate to vary around the world;

> "... burning biomass increases the amount of carbon in the air (just like burning coal, oil and gas) if harvesting the biomass decreases the amount of carbon stored in plants and soils, or reduces on going carbon sequestration."
> -- European Environment Agency Scientific Committee, 'Opinion of the EEA Scientific Committee on Greenhouse Gas Accounting in Relation to Bioenergy.' 15 September, 2011.

- The study concludes that society can help protect the climate by using paper more efficiently and avoiding wasteful 'low utility' uses such as junk mail, unsolicited catalogues, and needless packaging;

- By using paper that has more recycled fibre as a proportion of the total fibre, individuals and organisations can also help reduce paper's climate impact;

- The life cycle of paper causes such significant GHG emissions that paper efficiency should be a central part of all organisations' climate change policies and action plans.

The study is conservative in its approach: it used mostly industry data; there is a statistical reporting bias inherent in the data; and it does not include several factors that remain insufficiently documented, but that could alter the estimate were they to be included.

Forest biomass emissions have been included in the paper industry emissions figure. Many scientific authorities now recognise emissions from biomass to be a significant component of carbon footprints and not 'carbon neutral', as was previously widely assumed.

The analysis

In the studies reviewed, the carbon footprints of various paper products and paper production systems do not include the complete life cycle of paper. In many cases this is not due to poor analysis, nor is it an attempt to reach a desired result (e.g. demonstrating that the product does not have a significant impact on the climate). It is simply that the studies tend to focus on particular aspects of the paper life cycle, such as comparing different production methods or raw materials. The studies were, therefore, broken down into constituent

[4] A 'carbon footprint' of a product is the total emission of GHG that can be attributed to the production, use and disposal of a product.

parts in order to assess the range of climate impacts found for each segment of the life cycle.

It should be noted that this analysis is only indicative of the life cycle of paper in general. Specific situations will vary greatly depending upon the forest and soil type, the climatic zone, the specific fuel mixes used and the efficiency of pulp and paper mills and other equipment/processes. This analysis used FAO ForestStat 2011 data for the 2009 paper production globally. According to this source, virgin fibre accounted for 207.4 million tonnes (57%) and recycled fibre 154.5 million tonnes (43%) of paper, globally. Wood consumption quantities were taken from the Paper Task Force, based on data provided by, and peer reviewed by, industry participants.

Table 1: Emissions by segment, on average, across several studies

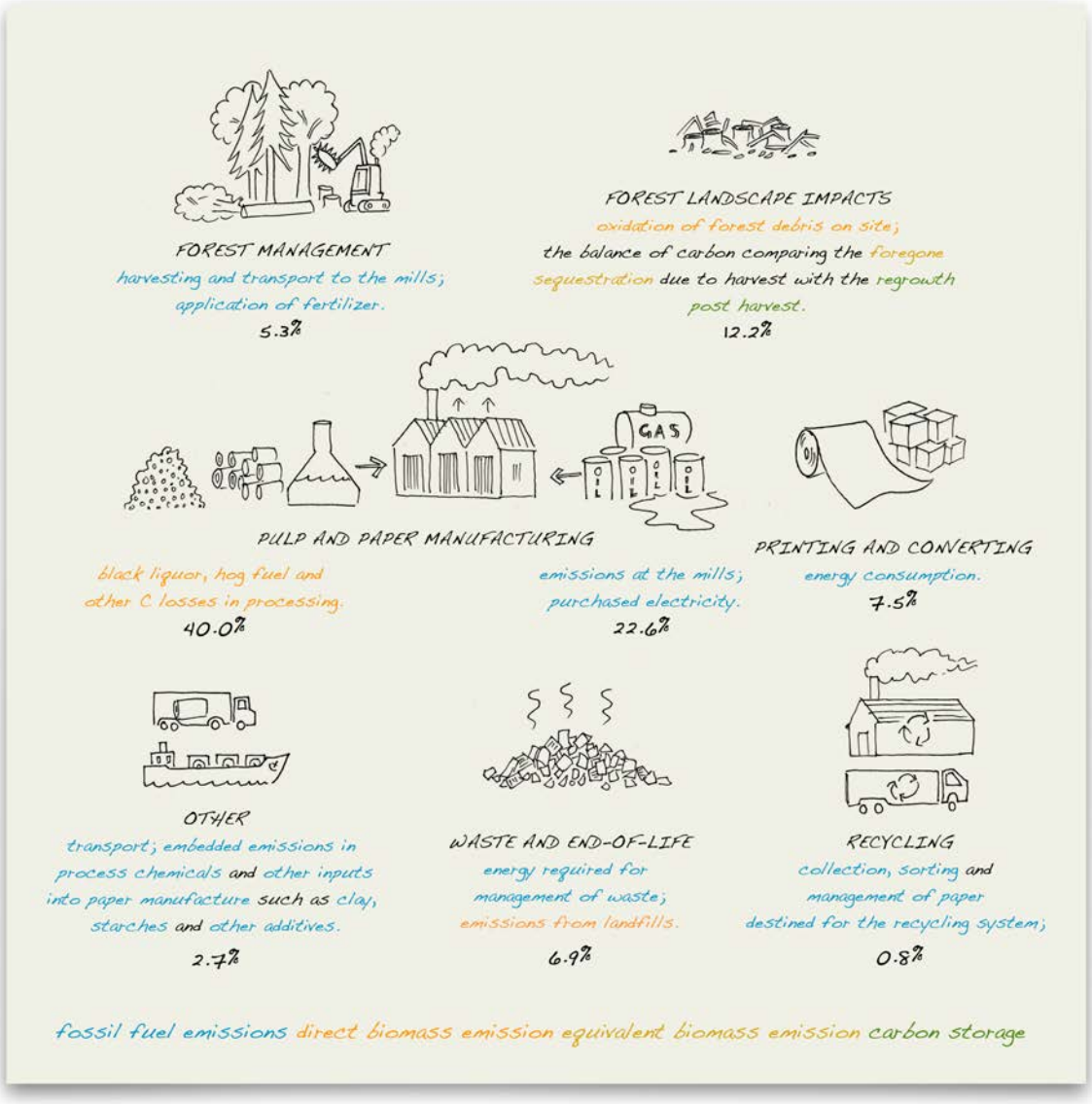
Production segment	Average value, virgin	Average value, recycled	Sources
	tonnes CO_2e / tonne of paper		
Tree harvest, transport	0.16	n/a	Environ, *Discover*, Paper Task Force / Paper Calculator, Time Inc., Axel Springer
Debarking and chipping	0.45	n/a	Energetics
Chemical production, other inputs	0.18	0.05	Environ
Pulp and paper manufacturing	1.66	1.31	Paper Task Force / Paper Calculator, Environ, *Discover*, Climate for Ideas, Energetics, EU
Converting, printing and other secondary manufacture	0.5	0.5	*Discover*, Climate for Ideas, Time Inc., Axel Springer, Book Industry Study Group
Waste disposal from manufacture	0.12	0.06	Environ, Climate for Ideas, Paper Calculator / Paper Task Force, Time Inc.
Distribution and other transport	0.13	0.05	Axel Springer, Time Inc., Climate for Ideas, *Discover*, NCASI, Environ
Recycling process	n/a	0.41	Environ, Paper Task Force / Paper Calculator, Climate for Ideas
Subtotal: fossil emissions	**3.2**	**2.38**	
Landfilling of paper (methane and CO_2 emissions)	0.64	0.64	Paper Task Force / Paper Calculator, NCASI, Borealis
Biomass impact	6.83	-0.1	Sachs and Ford, Newell and Vos, Climate for Ideas
Overall emissions total	**10.67**	**2.92**	
Recycling: carbon mass balance credit	0.73	0.61	Climate for Ideas
Overall total	**11.4**	**3.53**	

See the references at the end of this document for a full list of the studies from which the data in this table was drawn.

Table 2: Emissions by sector

Emissions Source	Contribution to global emissions
Deforestation	11.3%
Road transport	10.5%
Fuel and power for residential buildings	10.2%
Pulp and paper	**~7.5%**
Oil and gas production	6.4%
Fuel and power for commercial buildings	6.3%
Livestock and manure	5.4%
Agricultural soils	5.2%
Cement production	5.0%
Chemicals production	4.1%
Iron and steel production	4.0%
Air transport (excluding additional warming impacts)	1.7%
Agricultural energy use	1.4%
Aluminium and non-ferrous metals production	1.2%
Food and tobacco industries	1.0%

Source: Herzog, T. (2009) '*World Greenhouse Gas Emissions in 2005*'. World Resources Institute, Washington, DC., with the exception of the pulp and paper figure, which was calculated by Climate for Ideas for this analysis.



This analysis suggests that:

- The stages of the paper life cycle that have the greatest impact are: The direct and equivalent emissions from 'forest landscape impacts' that result from the release of carbon from trees and forest ecosystems (direct) and the net impact of the foregone sequestration, due to harvest and the regrowth of trees post harvest (equivalent)[5] (11.7%); the subsequent burning of trees for energy in the pulp and paper manufacturing process (direct) (40.3%); fossil fuel energy through the production system (direct) (21.7%); printing and converting (7.2%); and from the landfilling of paper, largely the result of methane emissions (direct) (10.6%)[6];

- Direct and equivalent carbon dioxide emissions from biomass at the forest and pulp mill levels generate more than 50% of the total paper life cycle climate impact;

- Transportation and distribution of pulp and paper, harvesting and management of forests and plantations, debarking and chipping of wood, the production of chemicals for use in paper-making, disposal of industrial wastes, and the recycling process itself each account for less than 7% of carbon dioxide equivalent emissions (CO_2e) per tonne of paper;

- When all segments are accounted for and an average assessed across the different studies, this analysis found that virgin fibre paper is responsible for 10.67 tonnes of CO_2e per tonne of paper on the product level. Recycled paper averages 2.92 tonnes of CO_2e per tonne of paper as a product (this includes a carbon balance credit for recycling – see below for further information);

- Given a global ratio of 57% virgin fibre and 43% recycled fibre used in paper, this gives an average of more than 7 tonnes of CO_2e per tonne of paper;

- The range of emissions for virgin fibre paper reported in the studies, all of which were incomplete at some level, was 0.7 to 11.88 tonnes of CO_2e per tonne of paper and for recycled paper, the range was 0.26 to 3.28 tonnes of CO_2e per tonne. The lower range of these estimates was often due to a very circumscribed analysis, such as not including a number of segments, production in regions where hydroelectric energy was the source (and thus counted as zero emissions) and excluding biomass emissions;

[5] Searchinger, T. (2010), 'Biofuels and the need for additional carbon', Env. Res. Lett. 5, 24007.

[6] Methane is a potent GHG, twenty-five times more potent than CO_2.

- Accounting for the recycling of paper means that the climate impact of paper products is reduced by approximately 0.65 tonnes of CO_2e per tonne of paper, on average, as a carbon mass balance allocation procedure[7];

- In total, when these averages were applied to the 362 million tonnes of paper produced annually around the world[8], it was found that paper potentially accounted for more than 2.8 gigatonnes of GHG in CO_2e;

- In 2009, global emissions were approximately 38.5 gigatonnes. This includes fossil fuel emissions and land-use impacts, plus additional emissions of nitrous oxides and methane, estimated at 14 gigatonnes[9]. Based on this figure, paper would be responsible for the equivalent of more than 7% of climate impact in terms of both direct and equivalent emissions, with direct emissions accounting for the vast majority and equivalent emissions estimated to be less than 5% of the total impact. The paper industry's direct emissions are more than a number of other industries including aviation, the production of iron and steel, chemical production and livestock management[10];

- Previously, the World Resources Institute (WRI) had estimated the share of GHG emissions from the pulp and paper sector to be 1.1% of global emissions[11]. However, that estimate only included fossil fuel emissions at pulp and paper mills and printing facilities and excluded most other segments of the paper life cycle.

[7] A system was adopted to allocate carbon from a product footprint based on the mass balance of carbon throughout. This allocation procedure is the most straightforward approach to attributing the benefits of recycling and requires few or no additional assumptions that might distort decision-making or analysis. End uses of paper that are regularly and easily recycled and in which a large proportion of the paper product is turned into another product, such as carton and boxboard, have a relatively higher reduction in emissions than products that are commonly not recycled, such as tissue products. Effectively, a given amount of carbon 'exits' the life cycle of one product and 'enters' the life cycle of another.

[8] FAO, ForestStat 2011.

[9] World Resources Institute (2005) 'Navigating the Numbers', Washington, DC. December 2005. International Energy Agency http://www.iea.org/newsroomandevents/news/2012/may/name,27216,en.html

[10] This figure does not include emissions from infrastructure, and neither does the figure for the pulp and paper industry, as is standard practice in LCA for all industries.

[11] World Resources Institute (2005), 'Navigating the Numbers', Washington, DC. December 2005.

Biomass emissions

It is commonly claimed that paper is 'carbon neutral' due to the apparent benefits of using wood biomass, a renewable energy source. The main benefit cited is that biomass energy effectively recycles carbon because the carbon released is taken up and stored by new trees as they grow[12]. Whilst it is true that all trees take up carbon and that wood is a renewable resource, it is an assumption to regard it as 'carbon neutral'.

"The notion of carbon-neutrality is based on the assumption that CO_2 emissions from bioenergy use are balanced by plant growth, but this reasoning makes a 'baseline error' by neglecting the plant growth and consequent C-sequestration that would occur in the absence of bioenergy production […]." -- Schulze, et al. 'Large-scale bioenergy from additional harvest of forest biomass is neither sustainable nor greenhouse gas neutral,' Global Change Biology, 2012.

When wood biomass is removed from a forest, it either goes into products or is lost to the atmosphere as CO_2 and methane, two principal GHGs. CO_2 is released into the atmosphere when wood biomass is burned to make energy for making paper. In fact, wood releases more CO_2 per kWh of energy than oil and natural gas do to generate the same amount of energy, due to its low energy density[13]. Other CO_2 biomass emissions occur when trees are felled: from the rotting of brash (branches) left on site, to the disturbance of other plants, to emissions from soil when it is disturbed during harvest and, later, prepared for replanting. Finally, most paper, as a general rule, only lasts a short time before going into the atmosphere as CO_2 or methane emissions from landfills[14]. All of these CO_2 losses from biomass together make up what has been termed 'carbon debt'[15].

[12] See for example: World Business Council for Sustainable Development. (2007) 'The Sustainable Forest Products Industry, Carbon and Climate Change. Key messages for policy makers': "Biomass energy is fundamentally different from fossil fuel energy because biomass recycles carbon to the atmosphere, whereas fossil fuels introduce 'new' carbon. This is why biomass is called 'carbon-neutral'."

[13] See IPCC 'Guidelines for National Greenhouse Gas Inventories', Chapter 2, Energy, pp. 1.19 – 1.20. 2006. The calorific content of wood is 15.6, crude oil 42.3 and natural gas 42.8, all in terajoules (energy) per gigatonnes.

[14] Smith, J., et al. (2005) 'Methods for Calculating Forest Ecosystem and Harvested Carbon with Standard Estimates for Forest Types of the United States,' US Department of Agriculture Forest Service. General Technical Report NE-343. 21 December 2005.

[15] Following the definition of Carbon Debt as set out in Searchinger, T. D. et al. (2009) 'Fixing A Critical Climate Accounting Error, Science.,' 326: 23. October 2009. Whether peat emissions are classed as 'carbon debt' or in another category of semi-permanent biomass loss is still debated.

In this analysis, emissions from soils (including peat) have not been included due to insufficient datasets. Emissions from drained peat, in particular, are known to be exceptionally high. In areas in which natural forest is cleared of peat, drainage channels dug and plantations for pulpwood established, emissions from land-use change make a very significant contribution to the paper industry's global climate impact. For example, in Indonesia it is estimated that 80% of the emissions are due to land-use change including the drying, decomposing and burning of peatland[16]. Further research is needed into the impact of peat drainage to obtain a reliable estimate[17].

In many forest situations, for example when natural forests are felled and especially when the forest has previously been largely undisturbed, it takes decades or even centuries to re-capture the quantity of carbon they stored prior to harvest and to recuperate the carbon debt. In some cases, losses may be near permanent, such as emissions resulting from the drainage of peat. In the meantime, had the forest been left to grow, it would have absorbed additional carbon, in most cases. This 'loss' has been termed the 'foregone sequestration' (see Figure 1)[18]. As Tim Searchinger stated in Science: "The loss of maturing forests and grasslands also foregoes ongoing carbon sequestration as plants grow each year, and this foregone sequestration is the equivalent of additional emissions"[19].

It is often stated that young trees absorb more carbon and do so quicker than older forests. However, this is not borne out by research which shows that trees under 25 years old absorb carbon more slowly than intermediate-aged trees (see Figure 2), except where management, and fertilizer use, are heavy. Undisturbed forests store vastly more carbon than forests and plantations that are managed for timber (see Figure 3). There are also situations in which

[16] Anon. (2010) 'Fact Sheet Norway-Indonesia Partnership REDD+,' May 2010. (See bar graph diagram. Data derived from IPCC reports and Indonesia National Council on Climate Change,) http://www.norway.or.id/PageFiles/404362/FactSheetIndonesiaGHGEmissionMay252010.pdf.

[17] For example, in the Sumatran province of Riau in Indonesia CO_2 emissions from acacia pulp plantations on peat soil (in the Kampar Peninsula, Riau, Sumatra) were measured between 78 tons/ha/year during the first 5 years and between 73 and 80 tons/ha/year in the subsequent years. See Hooijer et al. (2012), 'Subsidence and carbon loss in drained tropical peatlands,' and Jauhiainen et al. (2012) 'Extent of industrial plantations on southeast asian peatlands in 2010 with analysis of historical expansion and future projections'.

[18] Searchinger, T. D. et al. (2009) 'Fixing A Critical Climate Accounting Error' Science. 326: 23. October 2009; Schulze, et al. (2012) 'Large-scale bioenergy from additional harvest of forest biomass is neither sustainable nor greenhouse gas neutral', Global Change Biology; Searchinger, T. (2010), 'Biofuels and the need for additional carbon,' Env. Res. Lett. 5, 24007.

[19] Searchinger, T. (2008), 'Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change', Science 319, 1238.

plantations are established on low carbon stock lands and in which land-use change does not result in significant biomass emissions. Any consideration of equivalent emissions from foregone sequestration needs to be balanced with sequestration predicted from the regrowth of forests over a set timescale. The net balance will show a carbon debt or a carbon dividend over a given time period.

> "The accounting now used for assessing compliance with carbon limits […] contains a far-reaching but fixable flaw that will severely undermine greenhouse gas reduction goals. It does not count CO_2 emitted from tailpipes and smokestacks when bioenergy is being used, but it also does not count changes in emissions from land use when biomass for energy is harvested or grown. This accounting erroneously treats all bioenergy as carbon neutral regardless of the source of the biomass, which may cause large differences in net emissions."-- Searchinger, T. D. et al. (2009) 'Fixing A Critical Climate Accounting Error', Science 326: 23. October, 2009.

Many scientists agree[20] that the biomass burned or lost to the atmosphere must be accounted for in forest carbon footprinting; it is an 'accounting error' to exclude these emissions[21]. Full calculations and clear information are needed for decision-making, e.g. such as when considering whether fuel and material substitution to or from wood is appropriate. Currently, the common practice of counting biomass emissions as 'carbon neutral' means that clear comparisons are not often made. When society does not properly account for all emissions it can distort the facts and, thereby, decision-making about certain products or practices. For example, it is quite commonly believed that recycled paper has a higher carbon footprint than virgin paper because recycling mills rarely use a biomass energy source that can be counted as 'carbon neutral'. As outlined above, it takes significantly more energy[22] (and more chemicals and other inputs) to make virgin paper. Consequently, it has a higher carbon footprint. The need to account for biomass emissions applies whether we are making policy in government or choices about which production methods and products are best suited to a climate-constrained future.

[20] See for example the quotes in this document and in particular Schlesinger, W. H. et al. (2010) 'Letter to Speaker Pelosi and Majority Leader Senator Reid', Signed by 90 scientists. 17 May 2010.

[21] Searchinger, T. D. et al. (2009) 'Fixing A Critical Climate Accounting Error', Science 326: 23. October 2009; Schulze, et al. (2012) 'Large-scale bioenergy from additional harvest of forest biomass is neither sustainable nor greenhouse gas neutral', Global Change Biology

[22] For comparative energy use, see the 'Energetics Incorporated' study (2005) in the references. For comparative use of other resources, most studies will show this, including most recently the 'Environ International Corporation' study (2012) for National Geographic.

Carbon storage in a managed forest (conceptual model)

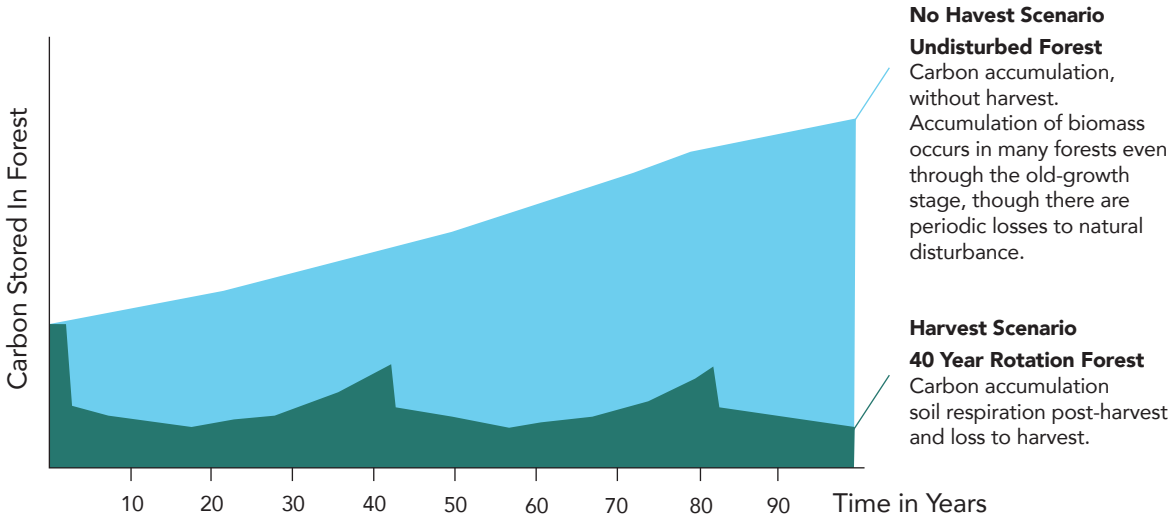


Figure 1. Forest harvest causes forests to remain at low levels of carbon storage, whilst allowing forests to grow increases the total landscape-level carbon storage. Managing forests for biomass energy and paper means more CO_2 is released into the atmosphere. The grey area in the figure represents the carbon lost from the ecosystem and opportunity costs, or 'foregone sequestration', of using forests for paper. Conceptual model developed by Climate for Ideas.

Carbon accumulation in mixed deciduous forests, Michigan, USA, at different stages since disturbance (Gough et al., 2007)

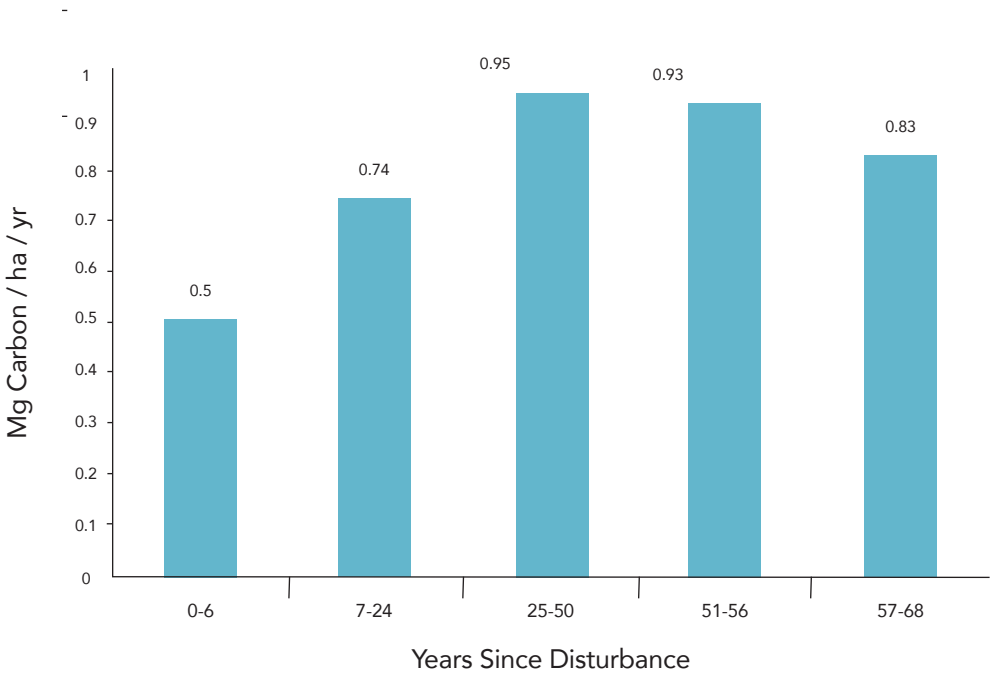


Figure 2. Young forests and re-planted forests accumulate carbon at a slower rate than older, natural forests in most cases. In general, continued harvest slows the ability of forests to absorb carbon from the atmosphere and thus prevents them from mitigating climate change.

Carbon storage per hectare under different management scenarios in Scotland
(Thornley and Cannell, 2000)

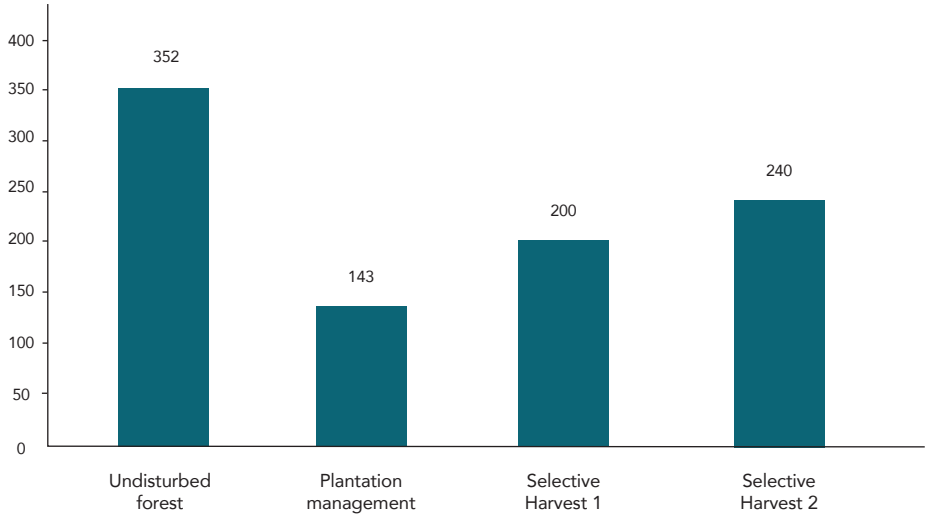


Figure 3. Natural forests store more carbon across the landscape than heavily managed (regularly harvested) forests and plantations. Were the amount of forest area that is heavily managed decreased, it would help them store more carbon and emit less CO_2 into the atmosphere. Were forest managers to use longer rotations and produced higher quality wood products, for example by increasing the quantity of wood used in construction and decreasing energy-intensive and high-emissions building materials, such as cement, it would also help reduce the impact that harvesting forests has on the climate.

Conclusions

This latest analysis explains the many sources of 'paper vapour' and demonstrates that GHGs are emitted at each stage of the life cycle of paper. It suggests that the production, use and disposal of paper accounts for more than 7% of all climate impacts, a share greater than many industrial sectors. This is a conservative estimate, based on available data. The EEPN intends this analysis to be part of an on-going effort to fully understand the impact that paper has on the climate and would welcome input. Further research and analysis is needed, especially into the emissions from forest soils and biomass.

It is clear, however, that the impact paper has on the global climate is a serious cause for concern and that society should reassess the ways in which it uses paper and value it more highly as a resource. An efficient way to reduce 'paper vapour' is to reduce 'low utility' paper use, such as junk mail or print overruns. Paper efficiency shrinks carbon emissions and should be central to any individual's efforts to reduce their carbon footprint and all organisation's climate change strategies, policies and action. Reducing 'paper vapour' by reducing low utility paper use can help organisations achieve their climate change targets, fulfil their sustainability criteria and can also result in significant financial savings.

Studies used in the assessment

More than 20 Life Cycle Analyses, Carbon Footprints and academic studies were used in this assessment. The studies from which we were able to draw data for this report are listed here. Other studies did not provide data in a way that was usable for this report[23]. Note that studies were taken from academic, non-governmental organisations and industry and all data points were used that could be fit into the major categories.

- Book Industry Study Group. (2008) 'Environmental Trends and Climate Impacts: Findings from the U.S. Book Industry.'
  - Data collected directly from industry participants and suppliers, with additional data the Paper Task Force.

- Climate for Ideas. (2009.) 'Carbon Footprint of Recycled Paper Mills.' Unpublished.
  - Direct observations from five recycled tissue mills.

- Climate for Ideas. (2008) '100% Recycled Papers made by Cascades: Greenhouse Gas Emissions Performance and Competing Products' August 2008.

- Discover Magazine (2008) 'How Big Is DISCOVER's Carbon Footprint?' 21 April 2008.

- Energetics Incorporated. (2005) 'Energy and Environmental Profile of the U.S. Pulp and Paper Industry' Columbia, Maryland. December 2005.

- Environ International Corporation (2012) 'Life Cycle Assessment of Deinked and Virgin Pulp', Denver, Co, November 2012.
  - Report for National Geographic.

- Environmental Protection Agency (2013) 'Forest Carbon Storage in EPA's Waste Reduction Model.' Washington, D.C.

- Gough, Christopher M., et al. (2007) 'The legacy of harvest and fire on eco system carbon storage in a north temperate forest', Global Change Biology 13, 1935 – 1949.

[23] Additional studies were examined, but the data was not in a format that could be used to provide input data.

- Gower ST, McKeon-Ruediger A, Reitter A, Bradley M, Refkin DJ, Tollefson T, et al. (2006) 'Following the Paper Trail: the Impact of Magazine and Dimensional Lumber Production on Greenhouse Gas Emissions', Washington, DC: The H John Heinz III Center for Science, Economics and the Environment.
  – Report commissioned by Time, Inc.

- Harmony Environmental, LLC (2009) 'Life Cycle Carbon Footprint, National Geographic Magazine.' October 1, 2009.

- Report commissioned by National Geographic Society.
  INFRAS. (1998) 'A Life Cycle Assessment of the production of a daily newspaper and a weekly magazine', Zurich.
  - Report commissioned by Axel Springer.

- Integrated Pollution Prevention and Control (European Commission), (2001). 'Reference Document on Best Available Techniques in the Pulp and Paper Industry'. December 2001.

- Manomet Center for Conservation Sciences (2010) 'Biomass Sustainability and Carbon Policy Study.' Brunswick, Maine. June 2010.

- Moore, S., et al. (2013) 'Deep instability of deforested tropical peatlands revealed by fluvial organic carbon fluxes.' Nature 493, 660–663. 31 January 2013.

- Miner, R (2003). 'Characterising Carbon Sequestration in forest Products Along the Supply Chain'. NCASI. December 2003.

- Miner, R. and Perez-Garcia, J. (2007) 'The Greenhouse Gas and Carbon Profile of the Global Forest Products Industry'. Special Report No. 07-02. NCASI. February 2007.

- Newell, J. and Vos, R. (2012). 'Accounting for forest carbon pool dynamics in product carbon footprints: Challenges and opportunities.' Environmental Impact Assessment Review 37 (2012) 23 – 36.

- Newell, Joshua P. and Vos, Robert O. (2011) 'Papering' Over Space and Place: Product Carbon Footprint Modeling in the Global Paper Industry'. Annals of the Association of American Geographers. First published 28 April 2011.

- Norway-Indonesia Partnership REDD+ (2010) 'Fact Sheet Norway - Indonesia Partnership REDD+'.

- Paper Task Force / Paper Calculator. White Papers Nos. 3, 10A, 10B, 10C, 11 and updating information for the Paper Calculator. 1995 – 2011.
  - Data provided by industry sources and updated regularly.

- Sachs, D. and J. Ford. (2013) 'Full Landscape Forest Biomass Carbon Accounting in Three Regions of North America and the Implications for More Accurate Life Cycle Analysis of Paper Products'. Publication pending.
  Stern, N. (2007). The Economics of Climate Change. The Stern Review. Cambridge University Press.

- Thornley, J. H. M., and M. G. R. Cannell. (1999) 'Managing Forests for Wood Yield and Carbon Storage: A Theoretical Study', Tree Physiology 20, 477–484. August 24.

- World Resources Institute. (2005) 'Navigating the Numbers', Washington, DC, December 2005.

The European Environmental Paper Network (EEPN), a coalition of 70 non-governmental organisations[24], commissioned this review and analysis of paper product carbon footprints as an initial scoping project to assess the global climate impact of the paper industry. The project was carried out by Jim Ford, of Climate for Ideas. The EEPN is committed to doing further analysis and research in this area and collaborating with the scientific community in this effort as more data become available.

This is a discussion document and its results are preliminary. Please send your feedback to:

Mandy Haggith, Co-ordinator, European Environmental Paper Network
95 Achmelvich, Lochinver, IV27 4JB Phone: +44 (0)1571 844020
Email: hag@environmentalpaper.eu
www.environmentalpaper.eu
www.shrinkpaper.org

[24] For a full list of EEPN member organisations see: http://www.environmentalpaper.eu/our-network/our-member-organisations/