Maximising carbon storage through sustainable forest management

Summary

This briefing draws on information from a range of recent studies to show how a policy of active forest management including sustainable timber production can offer significant carbon benefits compared to a strategy that relies only on forest preservation. It shows that forest management done responsibly can help to: prevent overstocking and reduce risks of catastrophic fire, disease, and insect infestation thereby protecting the long-term carbon storage capacity of forests; capture a portion of what would otherwise be natural mortality and associated release of carbon; create new carbon pools within long-lived forest products; and avoid substantial fossil carbon emissions when wood is used in place of high energy intensity products and materials, or when used as a source of energy in place of fossil fuels.

Available data on the carbon profile of U.S. hardwood forests and products suggests that their increased use is likely to have significant carbon benefits. However this briefing also highlights that it is not appropriate to draw far-reaching conclusions relating to individual products without robust information on specific forest management regimes, carbon emissions associated with processing, product fabrication, distribution, use and disposal, and opportunities for substitution. All wood supplying sectors need to focus on acquiring and communicating more product-specific information on their carbon profiles, and on encouraging energy-efficiency and production, design, and waste disposal measures to maximise carbon benefits.

The role of forests in carbon and climate mitigation may seem to be very straightforward. Since trees capture carbon as they grow and forests store massive quantities of it, it is easy to conclude that trees and forests should be treated as carbon sinks and left alone. But this kind of thinking reflects an incomplete understanding of the role of forests in carbon mitigation. In reality, forests have multiple roles to play in carbon mitigation, and forest management can help to optimize those roles (Bowyer et al, 2011).

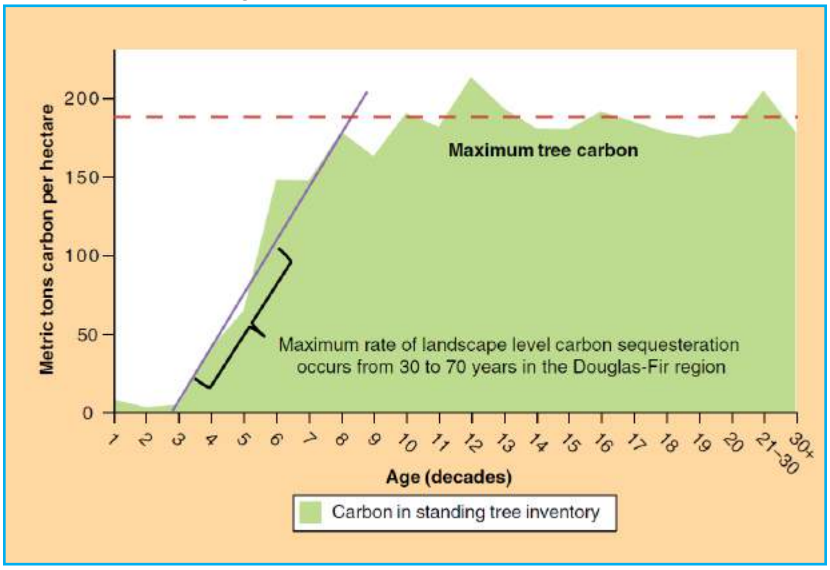
A range of recent studies of forest carbon relationships have argued that a policy of active and responsible forest management is more effective in capturing and storing atmospheric carbon than a policy of hands-off management that precludes periodic harvests and use of wood products (Fahey et al 2009, Lippke et al 2011, Perez-Garcia et al 2005, Society of American Foresters 2011). These studies lend support to the view expressed by the UN Intergovernmental Panel on Climate Change in their Fourth Assessment Report that: "In the long term, a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber, fibre or energy from the forest, will generate the largest sustained mitigation benefit."

Forest preservation versus active forest management

Young, healthy forests are carbon sinks. As forests mature, they generally become carbon cycle neutral or even carbon emission sources because net primary productivity declines, natural mortality increases, and the probability of massive carbon loss increases over time (Chart 1).

If a forest is unmanaged, decay of trees killed by natural disturbances—windstorms, fire, ice storms, hurricanes, insect and disease infestations—emits carbon without providing the carbon benefits available through product and energy substitution. Carbon storage decline in forest stands generally begins at 100 to 150 years of age as tree mortality losses increase, although there is variability among species and disturbance intervals. Therefore a no harvest strategy focused on increasing forest stocks can increase the volume of carbon stored in the forest in the near-term. However, a no-harvest strategy can increase the risk of loss to periodic natural disturbance and also means missed opportunities for greater carbon

Chart 1: Forest-carbon growth rate decreases



Notes: Data from western Washington State in the U.S. and derived from U.S. Forest Service Forest Inventory and Analysis inventory plot data. Forest carbon growth rates begin to slow before the age of 100 years with little to no growth after 100 years. Source: Lippke et al, 2011

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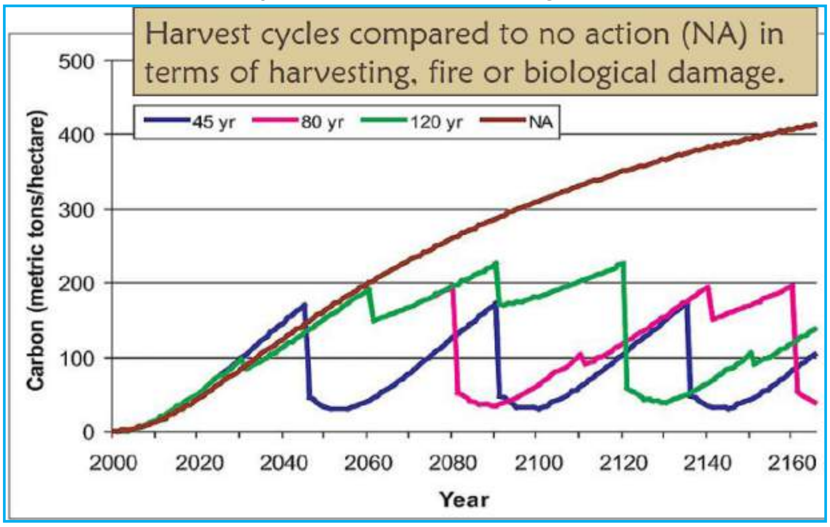
mitigation over the longer-term. Harvested wood products offer additional opportunities for carbon storage (carbon makes up a considerable proportion of wood volume, amounting to about 50% of the moisture-free weight) and can contribute to reduced consumption of potentially more carbon-intensive products.

Chart 2: Carbon in forest pools for different harvesting intervals



Notes: Data applies to the west Cascades area of the Pacific Northwest of the U.S.
Source: Perez-Garcia et al, 2005

Harvesting and Soil Carbon

In most forest ecosystems outside the tropics, a relatively high proportion of carbon storage is in the soil rather than the vegetation. In 2005–2010 in U.S. forests, some 24 to 25 billion metric tonnes of carbon were stored in standing trees, forest litter, and other woody debris, and another 20 to 21 billion tonnes were stored in forest soils and roots (U.S. EPA 2011). Therefore, the impact of different harvesting and forest management regimes on soil carbon may be an important factor influencing the overall carbon footprint of a wood product.

The effect of harvesting and replanting on soil carbon is difficult to generalize, as much depends on the initial soil depth, the intensity of harvest, and the strategies employed following harvesting to replenish the forest. Nave et al. (2009), after a review of 432 studies assessing responses of soil carbon to harvesting in temperate (non-tropical) forests worldwide reported an 8% average reduction in soil carbon stocks after harvesting over all forest and soil types studied. However these losses were mainly in the upper layers and are not permanent with recovery after 50–70 years. Therefore total soil carbon levels are likely to remain stable over the long term where harvest intervals exceed 70 years or under other less intensive harvest regimes.

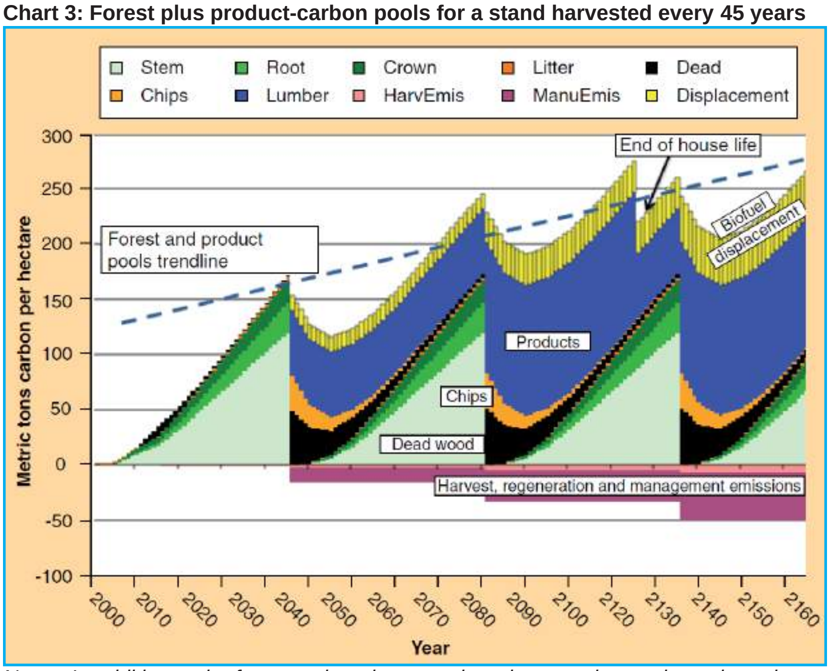
Changes in forest carbon pools over time in a single stand

Chart 2 shows how forest carbon pools evolve over time in a single stand harvested at different intervals. This is compared to the forest carbon pool in a stand which is not harvested (assuming no loss to natural agencies such as storms, fire and pests).

In the harvested stand, the forest carbon is restored at the end of each rotation, and remains stable over the long term as the new growth offsets the volume of removals used for products and biofuel. The average level of forest carbon storage is lower than in the stand where there is no harvesting (or loss due to natural agencies).

However, the picture may change when carbon storage in wood products is taken into account (Chart 3). Within some time frame the total storage from a sustainably managed forest producing products may exceed the carbon accumulation in an unmanaged forest. If harvesting leads only to relatively little forest and soil disturbance, and/or a high proportion of forest carbon removed is stored in long lived products, the combination of forest and product carbon stores may rise rapidly. However, if harvesting leads to particularly significant releases of carbon (e.g. from soils) and/or only short-lived products are produced, the product carbon

Chart 3: Forest plus product-carbon pools for a stand harvested every 45 years



Notes: In addition to the forest carbon, harvested products pools are shown based on life cycle inventory data for the U.S. Pacific Northwest along with the total harvesting and manufacturing emissions needed to produce them.
Source: Lippke et al, 2011

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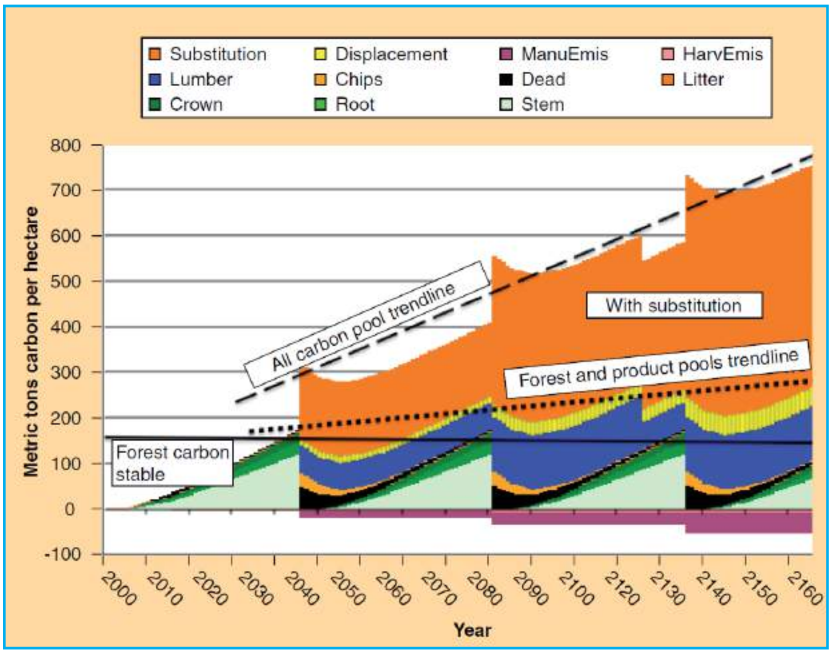
Chart 4: All carbon pools and substitution for a stand harvested every 45 years



Notes: In this model, which uses life cycle inventory data for the U.S. Pacific Northwest, the substitution benefit of using long-lived wood products provides the greatest carbon leverage of all pools, adding to the forest, products and displacement pools less any processing emissions that are incurred in production.
Source: Lippke et al, 2011

stored may not exceed the forest decay after the initial harvest.

Accounting for substitution

The most obvious missing carbon impact in Chart 3 is that which would have resulted without using wood. For every use of wood there are alternatives and every different product use results in a different life cycle carbon footprint impact.

A recent survey of 21 substitution studies by Sathre and O'Connor (2010) suggested that using one cubic meter of wood in place of other construction materials across a range of typical building applications reduces CO2 emissions by an average of 1.9 tonnes[1].

To show the potential carbon benefit of sustainable harvesting across all carbon pools, Chart 4 combines the Sathre and O'Connor average figure, with data on changing forest and product carbon stores resulting from forest management and net emissions due to processing of forest products. It suggests that when all carbon pools and substitution impacts are considered, there may be considerable benefits associated with sustainable management of forests for timber products.

Changes in forest carbon pools at landscape level

All the previous charts consider changing carbon pools at the level of an individual forest stand. However this is not a true reflection of sustainable forestry practices or of wood supply to a wood processing mill.

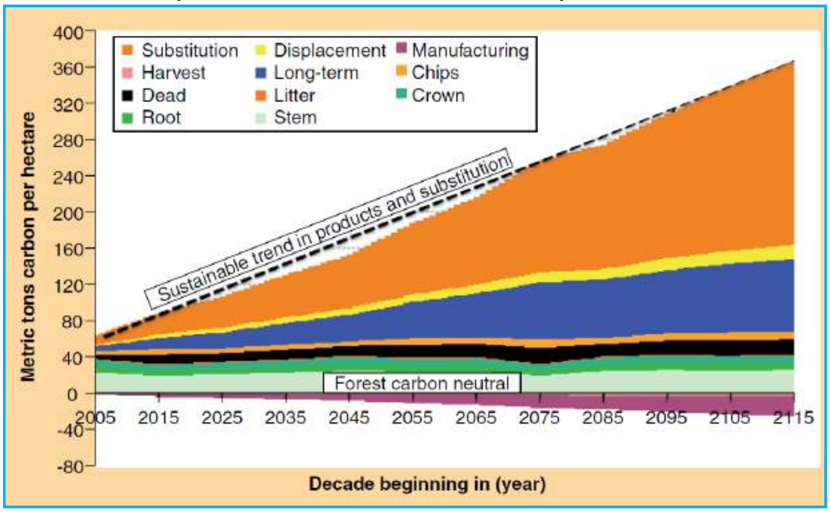
In practice, sustainable forest management is undertaken at a landscape level. The mature stands harvested each year are set within a mosaic of younger stands that are not harvested and are retained for wood production (and other forest values) in future years. Growth and removals across the area are kept in balance, and the loss of carbon from harvests in any given year will be at least equal to gains in carbon elsewhere in the forest management area.

Chart 5 illustrates how sustainable forest management across a landscape leads to a stable non-declining forest-carbon pool, a stable short-lived product pool after the initial rotations, with increasing long-lived products and substitution pools.

Factors influencing carbon storage potential

All this implies that managing forests for a sustainable supply of timber has potential to offer very significant carbon benefits. However, it is also important to highlight the many variables and data uncertainties involved. Carbon profiles vary widely between forest types, management regimes,

Chart 5: Landscape carbon accumulation in all carbon pools



Notes: Data relates to Inland U.S. Northwest forests. Sustainable forest management across a landscape shows a stable forest-carbon pool, a stable short-lived product pool after the initial rotations with increasing long-lived products and substitution pools.
Source: Lippke et al, 2011

[1] This comparison is not between 1 m3 of wood and an equivalent volume of building materials, but between 1 m3 of wood and the (very variable) amount of other materials required to do the same job across a wide range of applications. The figure is an average for 21 different studies assessed by Sathre and O'Connor across Europe and North America which included applications as varied as whole houses, individual apartments, whole office buildings, and specific flooring and door applications.

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product types and applications. Most of the charts shown here are derived from CORRIM, a research organisation based in north western USA and relate to forest types and products (mainly structural softwoods) in that region. It cannot be assumed that the carbon profiles apply equally to other regions and products.

However the existing data highlights factors which are most likely to influence the overall carbon profile of different forest products. The following measures will be important in maximising the carbon storage potential of forest products:

- They should derive from forests which are managed to ensure, at a landscape level, long-term maintenance (or enhancement) of carbon stored in forest eco-systems[2].
- There should be efficient extraction and use of wood fibre at every stage so that as much carbon as possible ends up in useful product.
- The focus should be on achieving a "cascaded" use of wood fibre, with priority attached to production of long-lasting wood products and with only fibre that would be otherwise wasted diverted for energy production.
- Priority should be attached to substituting sustainable wood products for those alternative materials which require particularly large inputs of fossil fuels during their manufacture (which might include, depending on local circumstances, plastics, aluminium, steel, and concrete).
- There should be a strong focus on end-of-life issues, with efforts made, where practical, to enhance continued carbon storage through recycling and, where this is not achievable, substitution of waste wood for fossil fuels in energy production.

Implications for US hardwoods

The available evidence relating to U.S. hardwood forests and products suggests that their increased use is also likely to have significant carbon benefits. This evidence includes:

- At a national level, data from regular government mandated forest inventories indicate that only a very small proportion of U.S. hardwoods are harvested every year, and rates of removal are well below growth rates with the result that there is considerable on-going accumulation of carbon in US hardwoods forests. Hardwood growing stock has more than doubled from 5.2 billion m3 to at least 11.4 billion m3 since 1952 and this growth has been universal across all hardwood producing states and commercial species groups.
- A land ownership structure in which around 90% of U.S. hardwood derives from private families and individuals, with each owning less than 10 hectares on average, means that harvesting areas tend to be small. Harvesting is typically by single-tree selection and rarely involves the complete removal of existing stands. This suggests that harvesting impacts on forest carbon pools, including soils, are likely to be relatively limited.
- Preliminary cradle-to-gate life cycle inventory data gathered by PE International for AHEC on U.S. hardwood lumber delivered to major export markets which suggests that the volume of carbon stored in the lumber is typically well in excess of the carbon emissions required to extract, process and deliver to any destination.
- Compared to many other wood products, American hardwood products tend to be durable and long-lasting.
- American hardwoods can be readily turned into useful products without the need for chemical and other additives, facilitating recycling or incineration at end-of-life.
- There are many applications where American hardwoods may be substituted for alternative potentially more carbon-intensive products (including flooring, cladding, furniture, window frames, doors).

While these general observations hold true at national level, it is emphasised that it is not yet appropriate to draw far-reaching conclusions relating to individual products containing U.S. hardwood without more robust information on specific forest management regimes, carbon emissions associated with processing, product fabrication, distribution, use and disposal, and opportunities for substitution.

References and Bibliography

Bowyer, J, et al, 2011, *Managing forests for carbon mitigation*, Dovetail Partners Inc, INC. www.dovetailinc.org

Fahey, TJ et al, 2009, *Forest carbon storage: ecology, management, and policy*, Front Ecol Environ 2009, doi:10.1890/080169, Ecological Society of America

Lippke, B, et al, 2011, *Life cycle impacts of forest management and wood utilization on carbon mitigation: knowns and unknowns*, Carbon Management (2011) 2(3), 303–333

Nave et al, 2009, *Harvest impacts on soil carbon storage in temperate forests*, Forest Ecology and Management, 259 (2010) 857–866

Perez-Garcia et al, 2005, *An assessment of carbon pools, storage, and wood products market substitution using Life Cycle Analysis results*, Wood and Fiber Science, December 2005, V. 37 CORRIM Special Issue

Sathre & O'Connor, 2010, *A synthesis of research on wood products and greenhouse gas impacts*, FP Innovations, Technical Report TR-19R, and Meta-analysis of greenhouse gas displacement factors of wood product substitution, Environ. Sci. Pol. 13(2), 104–114.(2010)

Society of American Foresters, 2011, *Managing forests because carbon matters: integrating energy, products, and land management policy*, Supplement to Journal of Forestry, October/November 2011, Volume 109, Number 7S

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[2] How this is achieved will vary according to local circumstances. In areas where forests are prone to natural disturbance (e.g. boreal forests), the best strategy may be relatively intensive short rotation forestry so as to minimise losses to fire and pests and to ensure rapid renewal of wood for useful products. In areas where losses to fire and pests are rare and 'old growth' forests common, it may be more appropriate to extend forest rotations to maximise storage in standing forests, and to engage in low intensity selection harvesting of only the most mature trees. Or some combination of these regimes may be most appropriate, in which some forest management units are set aside as permanent carbon (and biodiversity) stores while other adjacent units are managed for forest products.