Executive Summary:

The Impact of Forests and Forest Management on Carbon Storage

- a condensation of Manriquez 2002, and Bowyer et al 2002 -

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The Impact of Forests and Forest Management on Carbon Storage

***Introduction**: Many studies have noted that older forests generally store more carbon in the forest, hence reducing carbon concentrations in the atmosphere. Some studies have noted that the carbon pool in products is growing and is another important source of stored carbon. Recent studies show that the carbon emissions produced by the construction of steel or concrete buildings is considerably greater than it is for wooden buildings. The Kyoto protocol treats the flow of carbon from the forests into products as leakage, thereby ignoring the impact of management that supports the flow of wood into products, even though product storage is clearly increasing. This study tracks the movement of carbon from forest to forest products end uses, accounting for carbon storage and emissions at every stage of processing through to ultimate disposal. The displacement of carbon emissions from biomass energy conversion and substitution of non-wood materials are important aspects of a complete accounting system. A carbon tracking model is developed that forest managers can use to determine the impact of their management plans on carbon flows and storage pools. Reducing carbon emissions has become an international commitment and carbon trading or credit markets are developing. The objective of this project is to develop the full carbon cycle and carbon account as impacted by forest management decisions so that they can be supportive of constructive carbon policies.*

Developing carbon accounts for forests and their products:
The study develops carbon accounts for biomass carbon in the forest, carbon in the processing of products, energy displaced from biomass to energy conversion, and the displacement caused by the substitution of non-wood products. Particular attention is directed at the impact of alternative management scenarios including longer rotations, more intensive management activities and no-management. The consequences of changing the schedule of harvesting for products including a no harvest option are shown to have a substantial impact through the substitution of fossil fuel intensive non-wood products and energy sources.

Carbon movement at the forest level:
In the development of a forest, above ground carbon in the stems, canopy, and litter generally reaches a plateau but long after the economic age for removing biomass for products. Stand conditions impacted by management and other growing conditions determine the carbon content and are modeled by using growth models that can be calibrated to the species, growing conditions and treatment path. Carbon in the fine and coarse root structures is also linked to the growth model. The Landscape Management System (LMS) (McCarter et al 1998) provided a useful software platform for controlling growth models of the users choice so that each carbon pool can be computed for a given sequence of treatments over time. LMS is initiated with tree inventory or initial stocking data.

For the estimates of energy consumed in forest management, harvesting, processing and construction, the findings of a several year research project by a consortium of 14 research institutions across the US (mostly universities) were used. The Consortium for Research on Renewable Industrial Materials (CORRIM), a not-for-profit university lead government research group, developed a research plan in 1998 to study the environmental performance of wood by developing a life cycle inventory (LCI) data base of all inputs and outputs from forest regeneration, through harvest, processing, construction, building use and final disposal. Their interim report was presented at the Forest Products Society 2002 annual meeting and is available at (www.CORRIM.org).

Forests store carbon as they accumulate biomass until disturbances or natural mortality more than offsets growth. Disturbances can be natural (fire, windstorm, disease) resulting in decomposition of the biomass (carbon emissions) or a management treatment resulting in at least a partial flow of the biomass into product storage or energy production thereby displacing fossil fuel sources. Figure 1 shows the several pools of carbon in a Pacific Northwest forest under a near optimum economic rotation of 40 years.

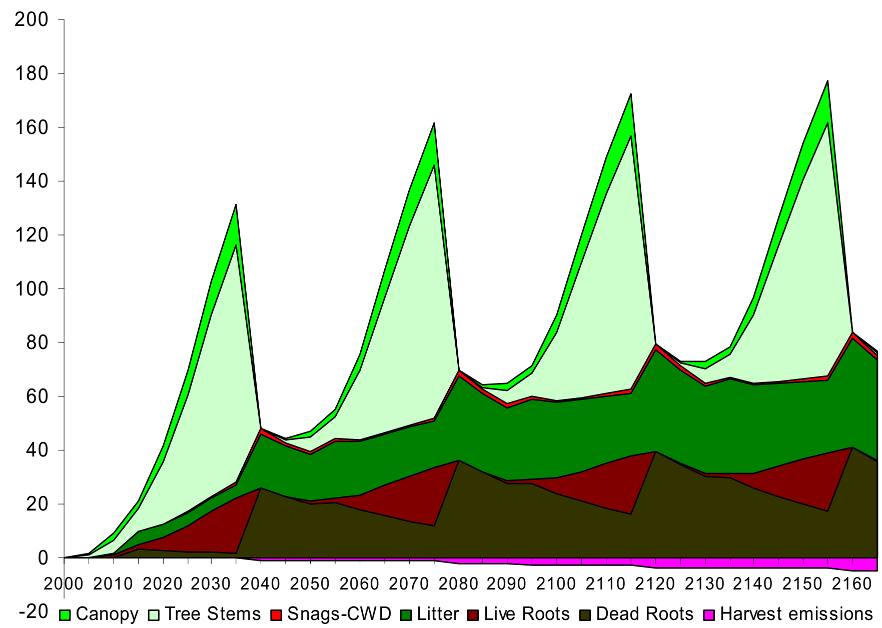

Figure 1. Forest carbon pools in metric tons/ha for the 40-year scenario (after harvests in 2040, 80, 120, 160).

In most carbon accounting budgets, forest harvesting is usually considered to cause a net release of carbon to the atmosphere (a decrease in the carbon storage pool) as is evident at the 40-year harvest points in Figure 1.

Figure 2 shows the net forest carbon for different management rotations. No-management is shown to store the most carbon in the forest with the pool decreasing with shorter rotations.

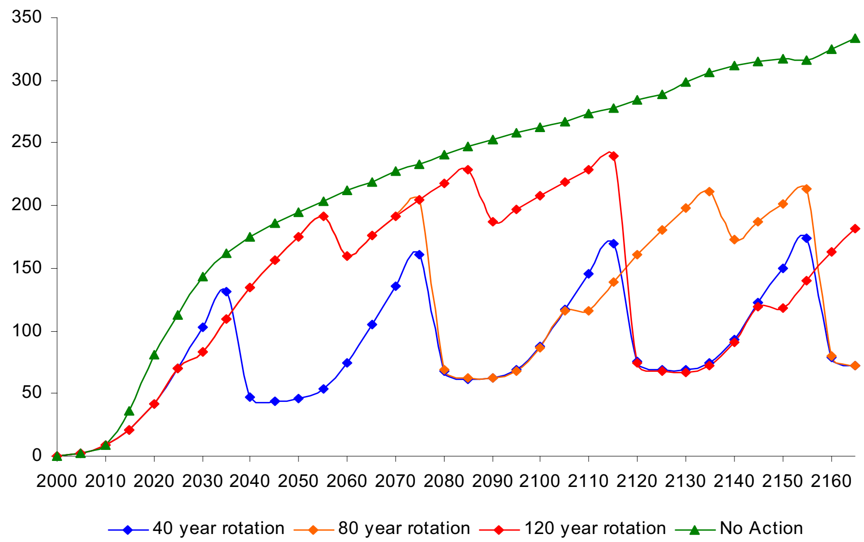

Figure 2. Net Carbon in the forest pools for all rotations through time in metric tons /ha, with emissions from operations deducted.

Afforestation (conversion from non-timber uses) with no harvest clearly produces an increase in carbon stored at least until growth is offset by mortality. Longer rotations clearly store more carbon in the forest than shorter rotations, roughly twice as much by doubling the rotation. However, if products are removed from the forest, the accounting is incomplete by drawing the boundary at the edge of the forest as the exported product pools must be accounted for before all carbon impacts can be determined.

Carbon movement at the products level:
Carbon pools from product processing were modeled by CORRIM based on mill surveys (Bowyer et al 2002). Roughly 50% of the biomass removed from the forest is processed into structural products for construction (lumber and plywood) with the remainder being co-products (wood chips, bark, sawdust and hog fuel) used mainly in short term applications or energy production. Short-lived products such as paper may enter the waste stream quickly and decompose (estimated at 10% decomposition per year). These co-product uses may involve additional processing and energy use and are assumed to carry their own share of environmental burden for those uses. Long-lived products such as those used in housing construction do not decompose if properly maintained, although there will be removals for social obsolescence reasons (estimated at 1% per year). Over half of the 80 year old US housing stock is still in use.

As more houses are built and the carbon stored in houses lasts longer than the rotation age, the products carbon pool accumulates from rotation to rotation. Figure 3 shows the products carbon pool which is substantially impacted by rotation age with the shorter (40yr) rotation age exceeding the products produced by the longer (80yr) rotation until the first harvest of the 80yr rotation. Carbon associated with the energy to produce the products is shown as a negative.

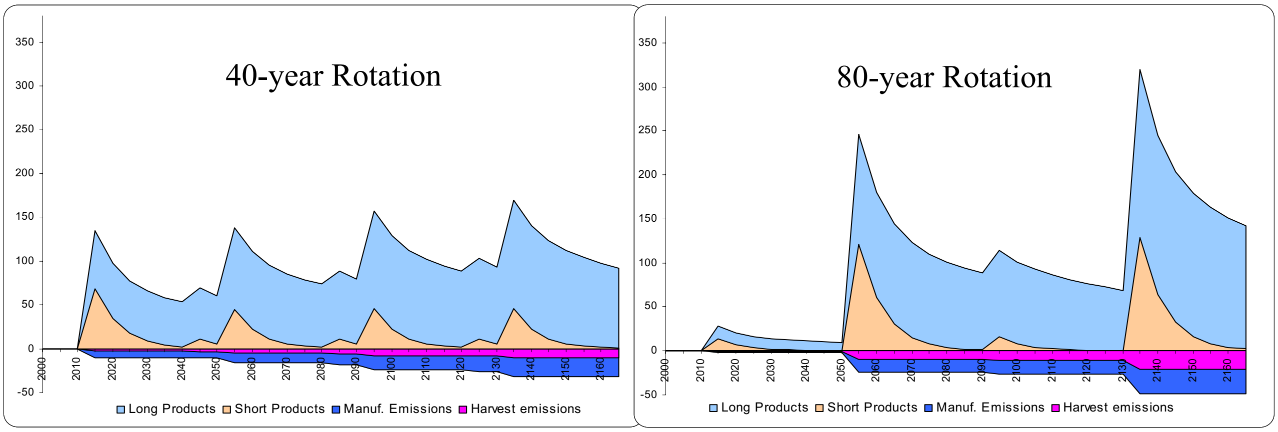

Figure 3. Carbon sequestered in products for 40- and 80-year rotations in metric tons per hectare.

If the short lived products are used as a biomass source for producing energy (co-generation), net electrical energy is added to the electrical grid, displacing fossil fuels, thereby providing another source of reduced emissions. While this biomass conversion is not subject to the decomposition of short lived products and therefore accumulates with every rotation, there is an energy conversion loss of about 50% compared to the initial carbon in short lived products as the efficiency of wood boilers is lower than natural gas or other fossil fuel sources. Figure 4 shows the carbon stored in the forest, in long lived products and the displacement of energy when the short term products are converted to energy. It takes several rotations for the biomass-to-energy conversion to significantly increase net carbon storage.

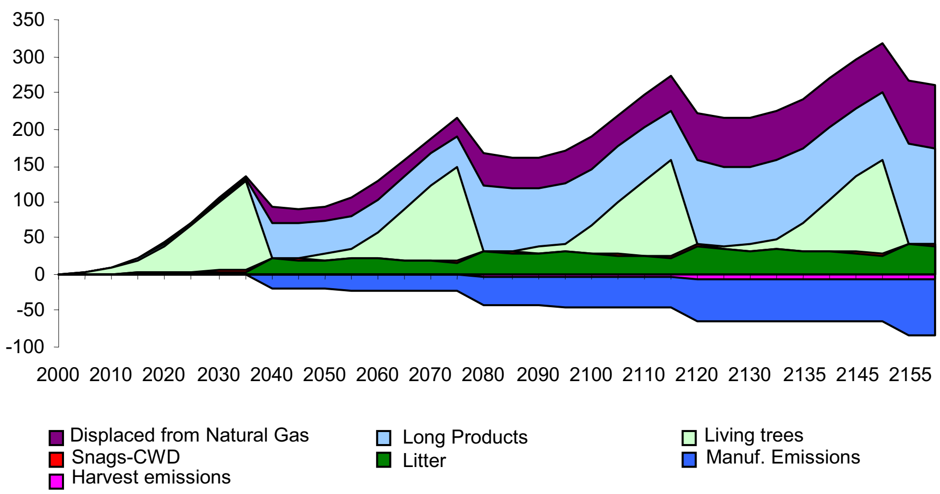

Figure 4. Carbon sequestered in the forest, products and energy displaced through time for the 40 year rotation in metric tons/ha.

Since the substitutes for short lived wood products are likely to consume more energy than their wood based counterpart, one should expect that the carbon stored in short lived products would be greater than their energy conversion value.

Carbon displacement from substitute products:
As noted in the products pool, Figure 3, long rotations or no harvest have a very negative initial impact on the product flow. Forests taken out of production or with delayed harvests result in the substitution of other products that are generally fossil fuel intensive like steel and concrete to cover any loss in wood products. The apparent benefits of long rotations on the carbon in the forest pool is more than offset by losses from the energy consumed in substitute products, Figure 5. The no-harvest option which produces no wood products is the worst case, requiring the greatest use of substitute products. While afforestation can increase the carbon stored in new forests, not ever harvesting that new forest foregoes the opportunity of increased product storage.

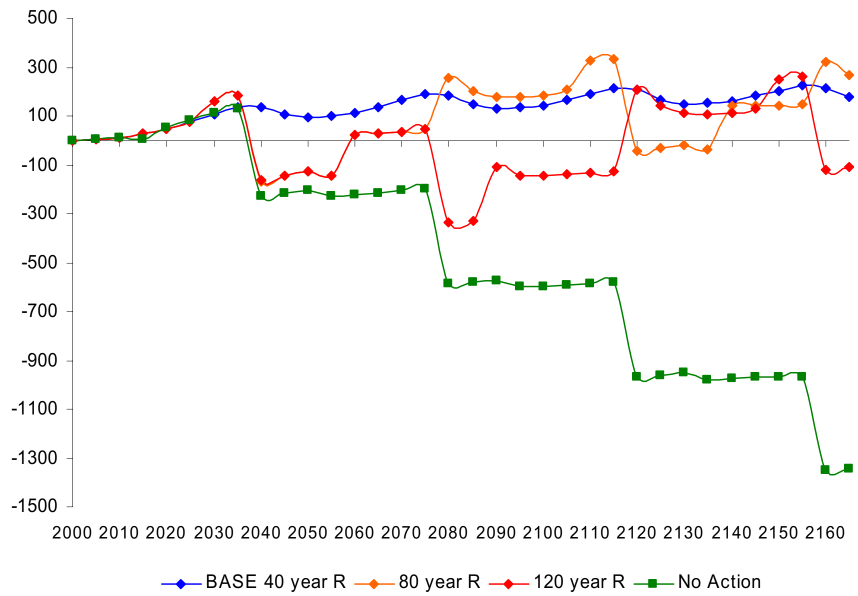

Figure 5. Net carbon substitution between steel and wood construction for all scenarios through the 165- year management period against the Base 40-year rotation, in metric tons/ ha of carbon sequestered showing affect of substitution between steel and wood design construction.

The case for intensive management:
While long rotations or no management (no products) requires substitute products that increase carbon emissions for a long period of time, more intensive management will generally increase wood product flows earlier thereby increasing carbon storage. For a 40-year rotation age, net carbon (all pools) increases from 56 metric tons per hectare on average to 83 with more intensive management, a 48% increase. Since the present value returns for these management scenarios are almost equal, yet many owners are not intensively managing their forest, presumably because of the increased effort and risk for little economic gain, there is the opportunity to substantially increase intensive management and carbon storage. Even small carbon incentives (credits) could substantially increase management intensity and carbon storage. An increase in intensity on half the private forestland acres in Western Washington could trigger a 60 million ton increase in carbon storage.

Summary of findings:
A carbon accounting system has been constructed for forest management from the forest to end-use markets. The system can be used by land managers to predict the impact of management treatments on carbon flows and stocks. Carbon in the forest, in products, the impacts of co-generation from biomass, and substitution among competing product alternatives are all included in order to capture all changes in flows. Contrary to the assumptions implicit in the Kyoto Protocol, the results show that shorter rotation ages do not lead to greater carbon emissions. They produce more products earlier than longer rotations or no harvesting, adding to the growing pool of carbon stored in products, largely in buildings. The so called leakage of forest carbon into product streams is actually the most important factor governing carbon storage derived from renewable wood products. Forests managed more intensively increase the productivity of the land base, producing more products and hence more carbon storage. Incentives for managing the forest to increase carbon storage has high potential, but only if all flows are recognized. It is the carbon stored in wood products that provides the opportunity to store more carbon and reduce emissions by using less fossil fuel intensive products. The land management objective to increase carbon sequestration should be to grow the most wood as soon as is economically feasible. Carbon credit systems properly administered would induce more intensive management of existing forests, and motivate sustained forest management. Conversions of forestland to non-forest uses would be reduced and could be offset by afforestation.

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