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Data report

Indicator 28. Contribution of forest products to the global carbon budget.

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## I. Analysis

### A. What is the rationale and guidance for this indicator?

#### 1. Rationale from the Technical Advisory Committee (TAC)

This indicator measures the role that forest products play in the sequestration, cycling, or emission of carbon. Harvested wood releases its carbon at rates dependent upon its method of processing and its end-use: for example, waste wood maybe burned immediately, paper usually decays in up to five years (although landfilling of paper can result in longer-term storage of the carbon and eventual release as methane or carbon dioxide), and lumber decays in up to 100 or more years. Provided the forest is fully regenerated, forest harvesting could result in a net reduction in carbon emissions if the wood that is harvested is used for long-term products such as lumber. In addition, where wood is used as a substitute for fossil fuels, there can be positive

benefits to carbon cycles. There is still scientific uncertainty and debate on accounting methodologies regarding wood products. The default assumption is that all carbon in harvested biomass is oxidized in the removal year. The net change in stocks of forest products should be a better indicator of a net removal of carbon from the atmosphere than the gross amount of forest products produced in a given year. New products with long lifetimes processed from current harvests frequently replace existing product stocks, which are in turn discarded and oxidized.

Interpretation from the Technical Advisory Committee (TAC) for the Montreal Process, as recorded in the Roundtable Report: Net increases or decreases in the sequestration of carbon from the production and use of forest products must be determined on the basis of a knowledge of changing wood manufacturing technologies and consumption.

## 2. Clarification of the indicator and additions to rationale

Reducing greenhouse gases such as carbon dioxide and methane through quantification, monitoring, and management is the goal of the United Nations Framework Convention on Climate Change (UNFCCC). The scientific basis of the convention relies heavily on information from the Intergovernmental Panel on Climate Change (IPCC). IPCC has published guidelines (IPCC 1997) for estimating greenhouse gas inventories, including carbon associated with land-use change and forestry. The TAC expects Indicator 28 to conform to the IPCC guidelines. The guidelines allow for appropriate country-specific values to be used in developing national greenhouse gas inventories. Current guidelines state that storage of carbon in forest products should be included in a national inventory only when a country can document increases in existing stocks of forest products. Otherwise, the default method is to assume that all carbon in harvested biomass is emitted in the removal year. The U.S. can provide scientific information that indicates its stocks of forest products are increasing.

Forest products is defined here as harvested wood that is removed from the forest. The remaining portion of trees that are cut and left in the forest is considered forest ecosystem carbon; this portion is counted as a pool in Indicator 26 and as a category of net change in carbon in Indicator 27. There is little information in the IPCC guidelines on how to estimate carbon in harvested wood.

One policy issue being debated is how to account for carbon in exported or imported products. Accounting options are discussed in Brown and others (1998), Lim and others (1999), and Winjum and others (1998). These include the stock-change, atmospheric-flow, and production approach. These methods differ primarily in how carbon storage and emissions in exports are assigned. If a country has no imports or exports of wood products, all three approaches would produce the same results.

## B. Data used in quantifying this indicator

This indicator reports trends in the contribution of carbon in harvested wood to the global carbon budget. Carbon is presented in megatonnes (Mt) or megatonnes per year (Mt/yr), carbon equivalent. One megatonne equals one million metric ton.

## Modeling approach used to estimate Indicator

Similar to Indicators 26 and 27, Indicator 28 is not measured directly. The change in carbon in products is estimated using data on the production of wood and paper products and on imports and exports over time rather than estimating the size of carbon stocks at two points in time. Data are not available to estimate carbon directly in, say, all housing at two points in time, or carbon in products in landfills at two points in time. Change in carbon in products and landfills over time is calculated using factors to convert production, imports, and exports to carbon contents, allotting these products to end uses, retiring them from use based on the end of their use life, transferring some of retired products to landfills, and estimating emissions over time from landfills. We summarize carbon in wood products in four categories: change in carbon in products in use, change in carbon in products in landfills, carbon emissions to the atmosphere from burning where energy was generated for use, and carbon emissions to the atmosphere where energy was not captured for use.

For the U.S., data on harvests and products are available from about 1900. Studies on carbon in harvested wood in the U.S. include Plantinga and Birdsey (1993), Heath and others (1996), and Skog and Nicholson (1998). For this indicator, data on the production of lumber, plywood and veneer, pulp and other products, product imports and exports, and fuelwood, million cubic feet of roundwood equivalent, are used as described in Skog and Nicholson (1998, 2000). A description of the model and associated references is given in Skog and Nicholson (2000). Primary data sources include the USDA Forest Service (1964), Ulrich (1989), and Howard (2001). Harvested wood-to-carbon conversion factors are from Birdsey (1992). Decay rates for waste wood in landfills, including methane production, and duration rates for carbon in wood and paper are in Skog and Nicholson (1998, 2000). Historically, net imports of harvested wood products in the U.S. have been small relative to domestic production. Only recently have net imports increased to more than 10 percent of domestic production (Howard 2001).

## Accounting approaches for reporting carbon in wood products

The three proposed accounting approaches are the stock-change approach, the atmospheric-flow approach, and the production approach (Brown and others 1998, Lim and others 1999, Winjum and others 1998). The stock-change approach measures the annual net change in carbon stored in products in a country, including carbon stored in imported products. The atmospheric-flow (drain) approach measures the annual net drain of carbon from the atmosphere to carbon stored in products in a country. Gross emissions from imported wood are included on the accounts of the importing country. The production approach measures the annual net change in the stock of carbon stored in products. The latter includes only the carbon harvested in a particular country, i.e., storage in products in the home country or in products exported to other countries. The atmospheric-flow approach accounts for carbon in exported wood products in the same manner as carbon in exported oil is treated. The other approaches address exports differently.

### 1. Overview

We used the stock-change approach to estimate carbon in wood products for 1900 to 2000 (Fig. 28.1, Table 28.1), that is, we estimate the annual net change in carbon stored in products in the

United States, including net imports. Table 28.2 includes estimates for 1990 and 2000 using the atmospheric-flow approach. We do not yet have estimates for the production approach.

Table 28.1—Change in carbon in wood products in use and in landfills, carbon emitted from products with and without energy production, 1910 – 1998, using the stock-change approach (Skog and Nicholson 2000).

Year	Change in products in use (1)	Change in products in dumps and landfills (2)	Total change in carbon stock in product (3)=(1)+(2)	Emitted by burning with energy production (4)	Emitted by decay or burning without energy production (5)	Total emissions from products (6)=(4)+(5)	Total wood carbon consumed (7)=(3)+(6)
Megatonnes per year							
1910	24.3	1.1	25.4	88.4	10.6	99.0	124.4
1915	21.4	2.0	23.4	88.4	12.5	100.9	124.3
1920	22.9	3.1	26.0	51.9	14.7	66.6	92.6
1925	20.2	3.7	23.9	51.9	16.4	68.3	92.2
1930	12.8	4.1	16.9	44.6	15.5	60.1	77.0
1935	11.3	4.3	15.6	44.6	16.6	61.2	76.8
1940	14.0	5.3	19.3	35.0	20.4	55.4	74.7
1945	14.5	5.9	20.4	36.5	23.2	59.7	80.1
1950	13.6	6.3	19.9	37.4	25.5	62.9	82.8
1955	11.2	6.8	18.0	37.3	28.3	65.6	83.6
1960	9.0	7.1	16.1	34.6	30.6	65.2	81.3
1965	9.9	8.0	17.9	27.3	31.4	58.7	76.6
1970	12.4	9.2	21.6	32.8	35.9	68.7	90.3
1975	7.8	16.9	24.7	37.8	28.7	66.5	91.2
1980	11.8	27.9	39.7	48.1	19.2	67.3	107.0
1985	16.5	32.9	49.4	62.1	13.8	75.9	125.3
1990	26	33.4	59.4	74.4	11.4	85.8	145.2
2000	25	32.5	57.5	88.1	14.3	102.4	159.9

Table 28.2— Removal of carbon from the atmosphere to wood products using the atmospheric-flow approach in Mt/yr (Skog and Nicholson 2000).

Year	Change in products in use (1)	Change in products in dumps & landfills (2)	Total change in stock of carbon in products (3) =(1) + (2)	Net imports of wood products (4)	Removal of carbon from atmosphere to wood products (5)=(3)-(4)
1990	26.0	33.4	59.4	2.3	57.1
2000	25.0	32.5	57.5	3.3	54.2

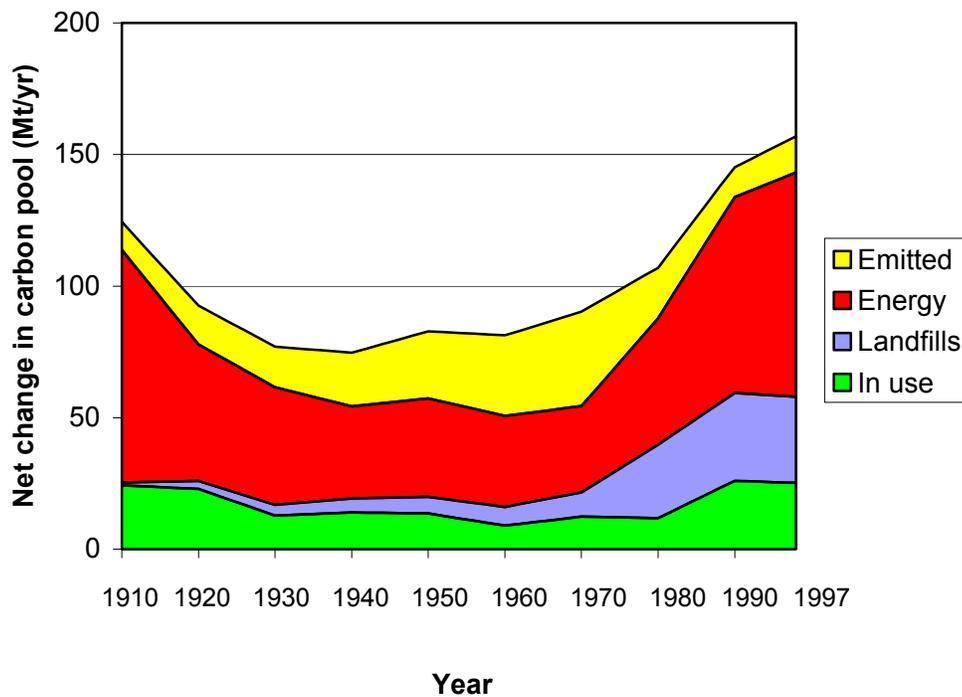


Figure 28.1—Net changes in carbon in harvested wood products (Mt/yr) for the United States, including carbon in net imports, 1910-1997 (Skog and Nicholson 1998). Note that all categories are shown as positive values, though the emitted and energy categories indicate the amount of carbon released to the atmosphere.

In Figure 28.1, all categories are shown as positive values, though the emitted and energy categories indicate the amount of carbon released to the atmosphere. Note that the carbon in harvested wood includes only that wood removed from the forest; logging residue left in the forest is excluded from these calculations. Early in the period, nearly 70 percent of the net change in carbon in harvested wood was emitted while being burned for energy as fuelwood, with about 20 percent sequestered in products and 10 percent emitted without energy production. These net changes in the carbon pool include transfers between categories from previous use, for example, carbon in products being discarded into a landfill, compared to the total amount of carbon harvested during that year. In the middle of the period, only about 45 percent of the net changes in carbon were attributed to carbon emitted while being burned for energy production; less than 20 percent sequestered was due to increases in products and about 10 percent was attributed to changes in landfill carbon. Net changes in carbon emissions without energy production climbed to 40 percent of the total harvested in a year, as previously harvested wood was discarded or decomposed or both. By the late 1980's, this pattern changed due to anaerobic landfills in which decay is arrested, and to more efficient use of waste wood for energy production. More than half of the net increases in carbon from harvested wood during one year results from wood burned for energy production, while carbon in in-use products changes about 17 percent, landfilled carbon 24 percent, and 9 percent in the category wood burned without energy production.

Between 1990 and 1997, about 60 Mt/yr were added to carbon stocks in the landfill and wood-in-use categories. If added to the estimate of carbon sequestration in forest ecosystems (Indicator 27), the estimate for the U.S. forest sector, excluding soil carbon, is about 195 Mt/yr for the 1990's.

Estimates of the cumulative fate of carbon in the U.S. from 1910 to 1997, including net imports, are shown in Figure 28.2. Note that all pools are shown as positive values for comparison purposes. The energy and emitted pools are cumulative emissions from harvested wood, that is, the amount that has been emitted to the atmosphere over the period. Neither pool will decrease because once emitted, carbon does not return to the in-use or landfill categories except for the small fraction of emitted atmospheric carbon dioxide that is taken up again by trees, stored in merchantable timber, and eventually harvested for wood products. The total amount of carbon in wood harvested between 1900 and 1997 is about 8,650 Mt, with nearly 2,700 Mt currently stored in products and landfills.

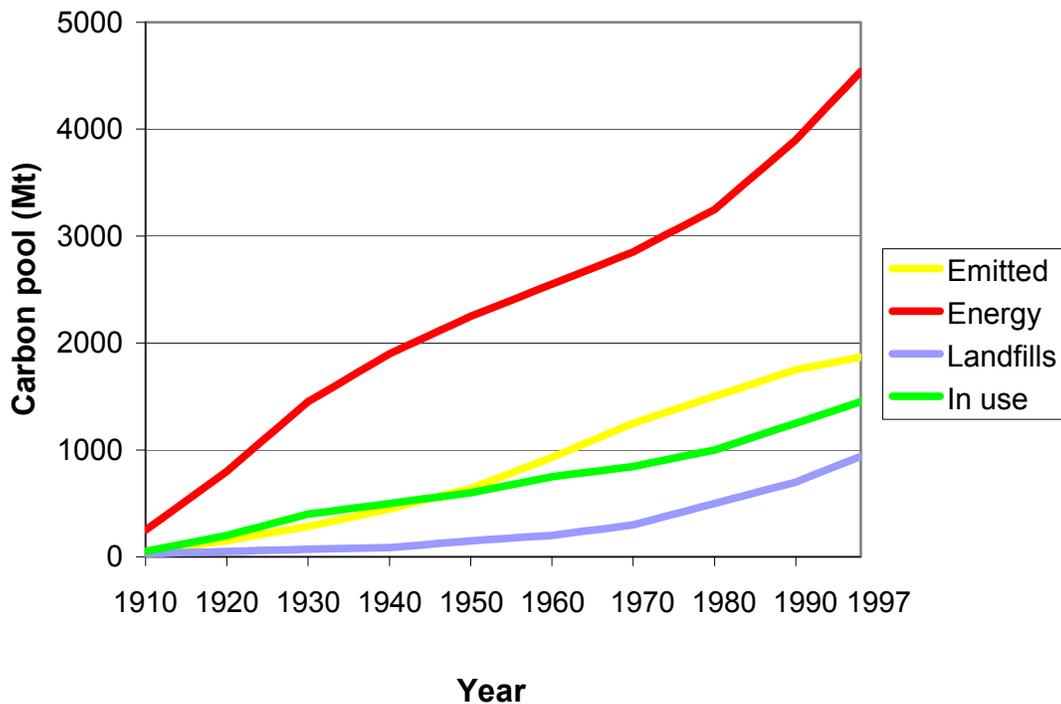


Figure 28.2—Cumulative disposition of carbon in harvested wood products (Mt) for the United States, including carbon in net imports, 1910 to 1997 (Skog and Nicholson 1998). Note that the emitted and energy categories are shown as pools of positive value for comparison with carbon in the in-use and landfills categories.

## 2. Regional trends

It is possible to suggest relative contributions of U.S. regions to carbon storage using the production approach by examining relative amounts of harvested wood by region (Fig. 28.3).

The proportions are relatively constant in the middle years, with the proportion of the southern region increasing and the proportion of the Pacific Northwest declining in recent years. These proportions assume that the life of products and disposal patterns associated with harvest are the same by region.

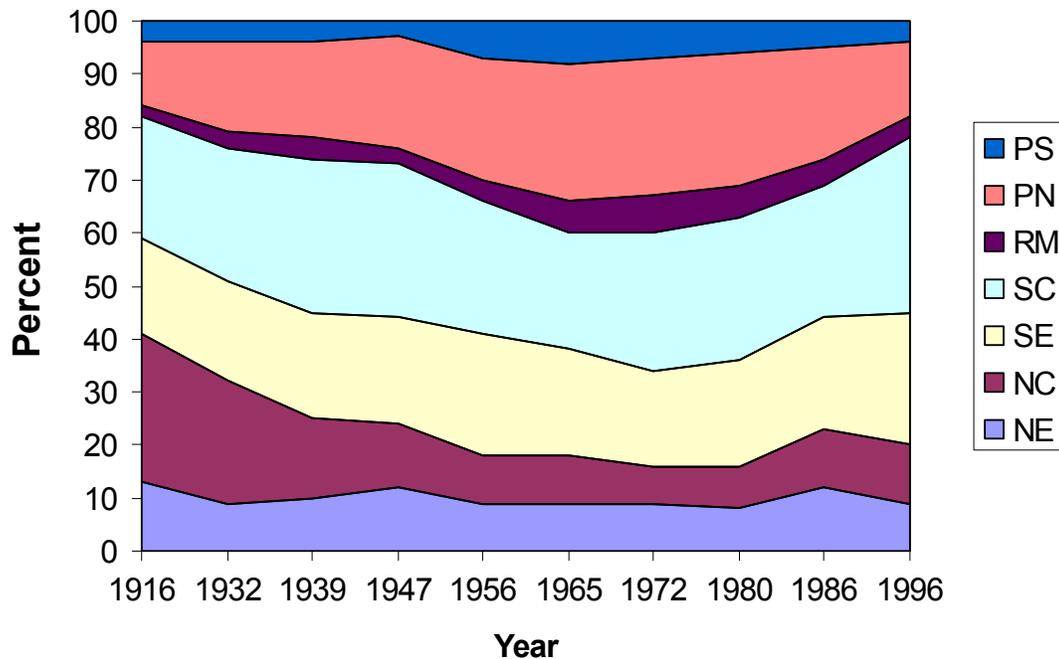


Figure 28.3— Proportion of roundwood products harvested in each U.S. region relative to total roundwood products harvested for the conterminous United States. The data were collected only periodically for the year indicated but were applied to every year of the period between data collection and the previous year of data collected. (PS=Pacific Southwest, PN=Pacific Northwest, RM=Rocky Mountain, SC=South Central, SE=Southeast, NC=North Central, NE=Northeast) Regions follow the regions in Smith and others (2001), with the exception that the Great Plains States are compiled with the NC region.

C. How should the data be interpreted relative to the rationale from the TAC?

There are several ways in which data on carbon in wood products can be interpreted that correspond to the three accounting approaches. Each interpretation meets the intent of the indicator to show the role of harvested wood products in sequestering carbon or limiting carbon emissions for a country or both. These interpretations should be coordinated with those of the effect of carbon storage in forests. In each case, the role of the forest is focused on net carbon additions, but the role of products can be viewed differently.

- The role of forests and products in a country in sequestering carbon in a given year includes net additions of carbon to forests, plus net additions of carbon to products, including net imports (stock-change approach).

- The role of forests in a country and products held in a country in draining carbon from the atmosphere includes the net additions of carbon to forests plus the net drain of carbon to products held (including imported) in the country (atmospheric-flow).
- The role of forests in a country and products originating from harvest in the country in sequestering carbon includes net additions of carbon to forests plus net additions of carbon to products using wood harvested in the country (production).

Separate additional information on the amount of wood burned for energy also indicates the contribution of wood energy in offsetting carbon emissions from burning fossil fuel. This amount has increased substantially in recent decades, particularly due to increased burning of pulping liquor and wood waste in pulp and paper sector, and of burning wood waste at solidwood product plants. In general, carbon stocks in wood products have been increasing in the last 3 decades both in absolute terms and as a proportion of all carbon consumed. This proportional increase is largely the result of increased use of anaerobic landfills and consequent estimated decreases in decay for discarded wood products.

#### D. Limitations of data provided

The data presented are based on a modeling approach that uses data on product production, use life, disposal, and decay. The accuracy of the estimates depends on the validity of the models and the data. The estimates are particularly sensitive to values used for the proportion of discarded products going to landfills or dumps, and the degree of decay in landfills and dumps.

A difficulty in estimating stock change for the production approach is the determination of use life and decay rates for products exported to other countries. Previous estimates of carbon in harvested wood products (Heath and others 1996) have used the production approach by assuming exports have the same use life, disposal, and decay rates as the United States. This assumption makes some experts uncomfortable. However, using the production approach for estimates of carbon in harvested wood products for regions of the U.S. or for States may be cost-effective and provide reasonable results. For the other approaches, each region must be treated as a separate country, because imports to and exports from the region are needed to estimate the amount of carbon in harvested wood.

E. If current data are not adequate to measure the indicator, what options are available for remedy?

The current estimates are considered a reasonable measure of indicator 28. For more precise estimates, a national survey could provide estimates of carbon in houses, other end-uses, and landfills. Another option is that additional research be conducted to verify decay rates and end-use estimates used in the current model.

#### II. Problems related to scientific, social/political, economic, and institutional concerns

The TAC expected the estimates in this indicator to match the IPCC guidelines (1997) and the trade (imports/exports) approach required by the UNFCCC. However, applicable guidelines currently have not yet been developed, and no decision has been made concerning the accounting

of carbon in imported and exported wood. The information in this indicator may need to be updated when these guidelines are available.

### III. Cross-cutting issues/relationships with other indicators

Indicator 28 is directly related to the other Criterion 5 indicators, 26 and 27. Indicator 26 is a measure of forest carbon pools; the live tree pools are significantly affected by the amount of wood harvested in the United States. Net change in forest carbon for Indicator 27 is estimated directly by subtracting forest carbon pools inventories at different times and dividing by years between inventories to produce annual changes in carbon. Changes in harvested wood carbon pools are not considered in Indicator 27. To understand the total benefits of forestry in retaining carbon stocks or reducing emissions or both, both forest and harvested wood components should be considered. See the discussion in section C above on interpretation. Indicators that provide measures of wood removals, such as 13, 31, and 33, should provide results consistent with the removals used in this Indicator.

### IV. Suggested guidance on use of the data

The underlying data on roundwood production have been collected after the harvested trees have been removed from the forests. Estimates of roundwood harvests based on USDA Forest Service's Forest Inventory and Analysis (FIA) surveys of forests are similar but do not exactly match estimates for the roundwood production. Thus, the two data sources may provide different estimates of harvested wood. The data on roundwood production are used because they are more detailed, and thought to be more accurate. However, estimates from Indicators 26 and 27 are based on FIA surveys. As a result, estimates based on summing the three indicators should be interpreted with caution.

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