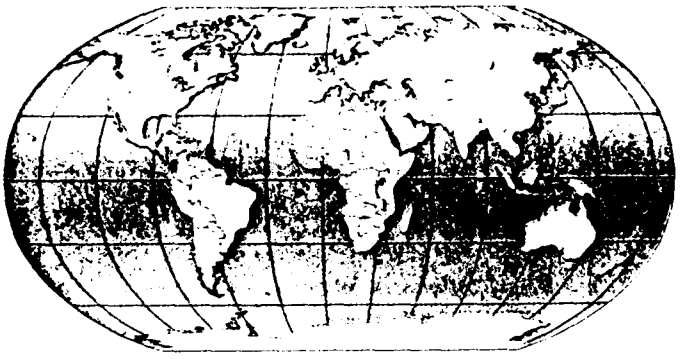

Recycling in the big picture — the really big picture

by Peter J. Ince, Kenneth E. Skog and Linda S. Heath

Recycling paper and wood can significantly reduce greenhouse gases.

The popular dictum is "Think globally, act locally." We might want to modify it somewhat to "Protect globally, recycle locally."

Poll after poll indicates that citizens connect recycling with saving the environment — by saving energy and water resources, reducing timber harvests and keeping recoverable materials out of landfills. But there may be another, larger benefit, one that will affect not just the environment in the United States, but that of all countries.

Recent research conducted by the Forest Products Laboratory (Madison, Wisconsin) found that 10 to 20 percent of the U.S. carbon reduction goal could be met through a range of scenarios for paper and wood recycling. More aggressive paper and wood recycling — as well as composting, source reducing and recycling other recoverable materials — can provide even more dramatic decreases.

What's the global carbon cycle and why should we care about it?

The scientific community warns us that the effect of significant increases in fossil fuel combustion, along with other human activities, have led to increasing concentrations of "greenhouse gases" in the atmosphere. Although there is much uncertainty and variability about the extent of the impact, it is generally believed that accumulation of greenhouse gases in the atmosphere contributes to global warming and climate change, with widespread negative environmental consequences.

Greenhouse gas emissions are often measured in carbon units (metric tons), because carbon dioxide accounts for the majority of the increase, with methane a distant second. The natural processes of photosynthesis, plant respiration and decomposition of vegetation play a significant role in the global carbon cycle. Trees play a special role because they can store, or "sequester," carbon over long periods in wood. Eventually, however, wood decays or is burned and carbon is released back into the atmosphere.

The global carbon cycle and the amount of carbon stored in wood are affected by such factors as the size of forested land areas, growth rates and mortality of trees, forest fires, timber harvesting, product demand, product recycling, and disposal of wood or wood products by landfilling or combustion.

In 1992, more than 160 countries came together at the United Nations Conference on Environment and Development (the Earth Summit) in Rio de Janeiro, Brazil to discuss environmental issues, including stabilizing greenhouse gas concentrations in the atmosphere. There, the United States joined other countries in signing an international agreement to address the danger of global climate change. In 1993, the Clinton Administration issued the Climate Change Action Plan, which recognized that the forest sector (forestry and forest products), among others, could play an important role in the global carbon cycle, and that forests are greenhouse gas "sinks" that could store carbon removed from the atmosphere by trees.

Looking at various scenarios

As part of the administration's commitment, the Forest Products Lab undertook an analysis of two principal ways that recycling could help mitigate the increase of carbon dioxide in the atmosphere.

First, paper and wood recycling tend to re-

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How recycling helps

- ✔ Recycling wood and paper reduces timber harvesting, increasing carbon accumulation in forests.
- ✔ Processing recyclables uses less energy than virgin pulp processing.
- ✔ Increased use of recycled wood products for construction could greatly decrease the greenhouse effect.

duce timber harvesting, and possibly delay tree harvest and lengthen rotation ages, leaving more carbon sequestered in forests. Second, paper recycling processes usually consume less energy per unit of product output than do virgin pulp production processes, so generally less carbon is released to the atmosphere because less fuel and energy are consumed.

We analyzed five different scenarios for recycling (see Table 1). We used an economic model to project how pulp and paper production might evolve in the U.S. (1). Using conventional assumptions of economic and population growth, we projected that overall production of pulp and paper will continue to expand, but recycling will play an increasingly important role.

The frozen technology scenario assumed that recycling and pulping capacities of the U.S. pulp and paper sector would remain fixed at 1990 proportions (i.e., at a 27 percent recovered paper utilization rate), but that production would increase, as projected in the base scenario. Now that recycling has increased, this type of scenario would be regarded as unrealistic, but it did provide a benchmark against which we could measure technological gains that were projected in other scenarios.

Our economic projections anticipated a significant turnaround in recovered paper prices, which actually occurred in the last year. This was projected to slow the rate of expansion in recycling capacity. Nevertheless, in our "base" scenario, we projected that the recovered paper utilization rate in the U.S. would climb from its current level of around 34 percent, to 38 percent by the year 2000 and 42 percent by 2010. Production of paper and board in the U.S. is projected to climb well above 100 million metric tons by the early part of the next century.

Because pulp and paper industry production is projected to shift toward increased use of recovered paper, less pulpwood, and therefore less fuel and less energy, are projected to be required per unit of product output on average. (In our analysis of energy impacts, we considered only the process fuel and the energy savings associated with shifting production processes over time. We did not consider the fossil fuels saved by harvesting fewer trees, nor the fuels consumed in gathering and delivering more paper to be recycled.)

Table 1 Elements of alternative paper and wood recycling scenarios

	Scenarios				
	Frozen technology	Base	EPA recycling options	Waste reduction	Recycled content in housing
Recovered paper utilization rates					
1993	27%	33%	33%	33%	33%
2000	27%	38%	37-39%	45%	38%
2010	27%	42%	42-43%	56%	42%
Recycled wood use in housing construction					
1993	*	*	*	*	*
2000	*	*	*	*	6%
2010	*	*	*	*	20%
U.S. timber harvest (million cubic meters)					
1991	-	506	506	506	506
2000	563	554	545-554	530	548
2010	609	588	575-593	565	571

* Conventionally, recycled wood accounts for only a small fraction of wood materials in housing construction, i.e., less than 1 percent; this proportion was varied only in the last scenario.
Source: Forest Products Laboratory, Forest Service, U.S. Department of Agriculture, 1995.

In the base scenario, a slower rate of growth in timber harvest was projected for the U.S. in the coming decades, largely as a result of projected gains in paper recycling (2). Recycling expands market demand for paper and wood products, because it increases overall fiber supply and production potential. Also, efficiency improvements in lumber and wood panel production will reduce the availability of wood chips for pulping and increase the proportion of roundwood in pulpwood consumption.

Nevertheless, gains in paper recycling were projected to slow the growth in overall timber harvest and allow more carbon to accumulate in forests. Sophisticated models of timber growth, timber harvest, inventory and carbon accumulation examined the impacts of recycling on timber growth and accumulation of carbon in forests (3).

The other scenarios were derivatives of the base scenario, showing how various changes in recycling or waste reduction policies might achieve different results. Five different policy options were obtained from a series of studies conducted in 1994 for the U.S. Environmental Protection Agency (4). The EPA policy options examined the effects of increased landfill tipping fees on recovered paper supply, federal procurement standards for recycled paper, investment tax credits for recycling, private sector minimum recycled content standards and waste reduction policies. The policy options scenario had modest impacts on projected trends in paper recycling, but in some cases, had significant impacts on timber harvest.

We also looked at a much more aggressive waste reduction scenario, which reflected the combined impacts of intensified paper collection programs, tax credits for recycling and more aggressive source reduction policies than were assumed in the EPA scenarios. The result was a more extreme and less likely waste reduction scenario (5).

Finally, we also derived a scenario to show what might occur if wood components in housing construction were gradually replaced by recycled materials, reaching 20 percent recycled content by the year 2010. Table 1 summarizes key elements of these recycling scenarios for comparison.

Recycling might also increase the average time that carbon could remain sequestered in paper and wood products. This effect was thought to be marginal for paper because paper has a relatively short product life span, whether it's recycled or not. However, for wood used in construction, carbon sequestration effects could be large if much greater quantities of recycled wood products were used in place of conventional lumber and wood panels in the future, if the recycled wood products would have a long lifespan and if future wood disposal techniques were similar to conventional techniques.

What we found

Table 2 summarizes the key findings of our analysis for the various scenarios.

Base scenario. The base scenario incorporated trends in paper recycling roughly consistent with current industry views (i.e., that 40 percent recovered paper utilization will be reached just after the year 2000, when the recyclable paper recovery rate would be around 50 percent.

As Table 2 shows, when compared with the frozen technology scenario, the base scenario reduces carbon cycling by nearly 10 million and 20 million metric tons annually by the years 2000 and 2010, respectively. The incremental gain from recycling alone by the year 2000 equals the entire goal proposed for the total forest sector in the Climate Change Action Plan. Thus, current industry trends in paper recycling are associated with significant carbon cycling effects; more aggressive recycling scenarios would surpass the goals.

EPA recycling poticy scenario. The EPA policy scenarios considered the impacts of various policy options. As Table 2 shows, these scenarios could result in significant additional carbon cycling effects. Among the EPA policy scenarios, the largest carbon cycling effects were those associated with waste reduction policies (chiefly, the reduced growth in product demand that could result from significantly higher disposal fees); the smallest effects were associated with proposed minimum recycled content standards for the private sector and prospective increases in recovered paper supply resulting from increased landfill disposal fees.

Waste reduction scenario. The wrote reduction scenario was a more extreme policy derivative of the base scenario, in which the U.S. recovered paper utilization rate was projected to reach 56 percent by the year 2010 (a rate higher than that projected currently in Japan, for example). This scenario may be regarded as a challenging one, because it was based on significant government policy intervention through substantially intensified paper collection and sorting programs, investment tax credits for recycling and much more stringent waste reduction policies. (Japan and Germany have already achieved recycled paper utilization rates that exceed 52 percent.)

Nevertheless, the waste reduction scenario might be regarded as showing an outside limit of what might occur through a much more intensified paper recycling effort in the future. As shown in Table 2, paper recycling under the waste reduction scenario could more than double the annual carbon cycling effects that were projected in the base scenario.

Recycled content scenario. As a final derivative of the base scenario, we computed the potential carbon sequestration effects of substituting recycled materials for 20 percent of the wood components in housing construction by the year 2010. In that case, recycling could offer upwards of 10 million metric tons of additional carbon sequestration in forests by the year 2010.

This scenario may also be regarded as potentially achievable, though somewhat less than likely, because it would require substantial product research and development efforts, coupled with large-scale market development and building code acceptance of new recycled construction products in place of conventional wood products. Also, we did not compute the effects of such developments on manufacturing energy requirements, which may be higher for recycled housing materials than conventional wood products.

Table 2 **Estimates of carbon cycling effects for alternative recycling scenarios (in million metric tons, carbon equivalent)**

	Scenarios				
	Frozen technology	Base	EPA recycling options	Waste reduction	Recycled content in housing
Carbon sequestration in forests, annually					
2000	169	174	174-179	186	177
2010	190	200	198-207	213	209
Carbon emissions from energy and fuel use in pulp and paper sector, annually					
2000	101	97	97-96	94	97
2010	116	106	106-99	90	106
Reduction in carbon cycling relative to frozen technology scenario, annually (1)					
2000	-	9	9-15	24	12
2010	-	20	18-34	49	29

(1) The reduction in carbon cycling is the sum of increases in sequestered carbon and decreases in carbon emissions.
Source: Forest Products Laboratory, Forest Service, U.S. Department of Agriculture, 1995.

As recycling rates for paper and wood products increase, disposal rates for wood decrease. As more wood and wood fiber material are recovered for recycling, proportionately less will be landfilled and incinerated (this includes material in products and by-products such as paper mill sludges and spent pulping liquors). In the long run, the reduction in landfilling and incineration of wood and wood fiber due to increased recycling will be roughly equivalent to the reduction in wood raw material use. This will contribute further to reducing carbon emissions from landfills and waste incinerators. However, because of uncertainty about the relatively slow rates of decay of wood and paper in landfills and uncertainty about actual proportions of waste paper and waste wood that are landfilled and incinerated nationwide, we did not attempt to quantify these effects.

Summary

We projected the effects of increased paper recycling on atmospheric carbon sequestration in forests and carbon emissions from process fuel and energy use. By the year 2010, these effects might reduce atmospheric carbon by 20 million metric tons annually, based on current trends in paper recycling.

These effects could be enhanced by policies that could result in further increases in paper recycling and waste reduction. In addition, increased use of recycled materials in place of wood in housing construction (e.g., 20 percent by 2010) might potentially sequester additional carbon in forests (upwards of 10 million metric tons per year by 2010). Other efforts, such as source reduction, comporting and recycling of other recoverable materials, could also enhance carbon cycling.

The estimates presented in this report were based on economic projections and are subject to a large degree of uncertainty. Trends will be influenced by other future economic and policy developments. Also, we are not yet capable of providing a comprehensive lifecycle assessment of all the carbon cycling implications of paper and wood recycling, nor do we claim to do so in this report. Regardless of these caveats, our analysis shows that increased paper and wood recycling in the U.S. could contribute significantly to stabilizing atmospheric concentrations of greenhouse gases over the next 15 years. **RR**

Footnotes

(1) Ince, Peter J., Forest Service, U.S. Department of Agriculture, *Recycling and Long-range Timber Outlook*, General Technical Report RM-242, 1994a; Ince, Peter J., Forest Products Laboratory, Forest Service, U.S. Department of Agriculture, *Recycling and Long-range Timber Outlook*, Research Paper FPL-RP-534, 1994b.

(2) Idem.

(3) Birdsey, Richard A. and Linda S. Heath, "Carbon changes in U.S. forests," in Linda A. Joyce (ed.), *Productivity of America's Forests and Climate Change*, Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, in preparation.

(4) Marcin, Thomas C., Irene A. Durbak and Peter J. Ince, "Source reduction strategies and technological change affecting demand for pulp and paper in North America," in *Proceedings of CINTRAFOR Third International Symposium on Pulp and Paper*, 1994, Center for International Trade in Forest Products, University of Washington.

(5) Ince, op. cit.

on recycled paper