Potential Impacts of Source Reduction Policies on Pulp and Paper Markets in the United States

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POTENTIAL IMPACTS OF SOURCE REDUCTION POLICIES ON PULP AND PAPER MARKETS IN THE UNITED STATES

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ABSTRACT

This paper describes an analysis of potential long-term impacts of two types of source reduction strategies for managing paper and paperboard waste: strategies primarily affecting demand and those primarily affecting supply. Separate scenarios defined for these policy strategies were incorporated into an economic model of the North American pulp and paper sector, NAPAP. Scenario A represents policies that result in a negative shift in demand as a result of change in consumer preferences over time. Scenario B represents policies that result in a negative shift in supply as a result of increased costs related to production. The NAPAP Model was also used to develop projections for a Base Scenario for comparison. Results indicate that over time both types of strategies could reduce the rate of growth in U.S. consumption and production of paper and board products. Paper recovery for recycling would increase and the wastepaper disposal burden would decrease. The rate of growth in U.S. pulpwood supply and consumption would also decrease. In general, supply-side strategies, such as mandatory disposal fees, would have a more immediate impact and a slightly greater long-term effect. A combination of demand-side and supply-side strategies may achieve the best results. Growth in the aggregate net social surplus calculated in the model would decrease in line with projected trends in U.S. consumption and production.

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INTRODUCTION

This paper presents results of a study conducted in 1993 by researchers at the Forest Products Laboratory, USDA Forest Service, which assessed potential long-term market impacts of public source reduction strategies for paper and paperboard materials (Marcin et al., 1994). Two related issues led to this study: (1) increasing amounts of greenhouse gas emissions and their perceived effect on world climate change, and (2) increasing amounts of municipal solid waste and the landfill problem.

Combustion of fossil fuels in ever-increasing amounts throughout the world, together with other activities, has been gradually raising the levels of greenhouse gases such as carbon dioxide, methane, and nitrous oxide in the atmosphere. The buildup of these gases is believed to cause a gradual warming of the atmosphere, which in turn could lead to global climate changes with serious consequences, such as decreased food production and increased forest fires and floods (see Clinton and Gore, 1993; Flavin and Tunali, 1995). Although the magnitude of projected impacts has been controversial, there is general agreement that steps need to be taken to reduce gas emissions and thus help protect the environment.

With that goal in mind, leaders of more than 100 nations met at a summit meeting in Rio de Janeiro in June 1992 and drafted the Framework Convention on Climate Change. This document calls on nations to find ways to reduce gas emissions, suggesting that industrial countries take the lead and return emissions to 1990 levels or below by the year 2000. More than 160 nations have signed the Convention, including the United States (Flavin and Tunali, 1995). This historical event led to various studies aimed at assessing the problem of gas emissions in the United States and finding ways to reduce emissions. The Climate Change Division of the Environmental Protection Agency (EPA) was charged with organizing analyses of policies and actions that could potentially reduce emissions. The USDA Forest Service has been involved in one area of analysis—carbon sequestration in forested sinks—through a 1993 interagency agreement with the EPA.

Living trees can remove carbon from the atmosphere and store it in wood fiber. Harvesting trees reduces this potential. However, even after harvesting, wood products such as paper and paperboard, continue to store carbon in wood fiber until they decompose as waste or are burned. The carbon is then released back into the atmosphere. Paper recycling and reduced production of paper products can promote carbon sequestration in forests by leaving greater inventories in forests and by reducing fuel consumption in production processes (Ince et. al., 1995).

The quantity (by weight) of municipal solid waste (MSW) generated in the United States more than doubled during the last 30 years (EPA, 1994). In 1993, paper and paperboard materials constituted the largest portion of MSW, almost 38% of total weight. Even though the overall recovery rate for all materials in the MSW stream for recycling or composting tripled during this same 30-year period, more than half of the materials were nevertheless landfilled. In 1993, more than 60% of total MSW (by weight) was landfilled. Paper and paperboard materials made up the
largest portion of the total volume landfilled (EPA, 1994). Landfills, however, have been fast approaching capacity limits throughout the United States, and landfilling is no longer considered a feasible long-term option for waste management (EPA, 1989). Recycling of paper and paperboard would reduce the amount of MSW, help ease the landfill problem, and also increase carbon sequestration. Source reduction would achieve similar results by reducing the amount of paper produced and consumed before it becomes part of MSW.

In response to a request from the EPA, researchers at the Forest Products Laboratory, USDA Forest Service, conducted a study to identify and analyze types of policies and actions that would promote recycling and source reduction. Here we describe the results that pertain to source reduction.

**STUDY METHODS**

**General Study Approach**

Historical and projected trends in consumption of paper and board in the United States were compared with trends in Canada, Japan, West Germany, the United Kingdom, and Sweden. These countries, as a group, were assumed to be sufficiently similar to the United States in economic development to allow comparisons.

We assumed that consumption in the United States could potentially be reduced to the average consumption level in this group of countries. A projection to the year 2040 of the average historical consumption trend for these countries was used to estimate a feasible long-term target or goal that could be set for U.S. source reduction efforts. This projection was made using a regression equation based on the historical trend in per capita consumption, with no additional source reduction efforts assumed. A base projection, to the year 2040, was also made for U.S. per capita consumption of paper and board based on current and expected trends, with no additional source reduction efforts assumed. This "Base Scenario" was made using the North American Pulp and Paper (NAPAP) Model. The difference in projected levels of consumption was used as a rough estimate of the potential for source reduction in the United States.

Review of recent discussion and proposals in the literature on source reduction strategies provided insight into the range of possibilities for source reduction efforts. We concluded that two general types of strategies could be followed: (1) a strategy relying on policies that affect consumption patterns over time and (2) a strategy relying on policies that affect supply patterns. Both types of strategies were analyzed and are presented in this report as Scenarios A and B, respectively.

On the basis of these alternative types of strategies, we made two separate sets of assumptions, which were incorporated into the NAPAP Model. The model was then used to develop separate projections, to the year 2040, of the potential reductions in U.S. consumption and related impacts, for each scenario. The Base Scenario was used to compare results.
Assumptions

We assumed that source reduction efforts would act to reduce future rates of growth in demand through more efficient use, reuse, or more limited consumption of end products. This would lead to less waste and less use of raw materials, mainly pulpwood. Source reduction strategies can be implemented in three ways: (1) education and voluntary compliance policies by businesses and consumers, (2) fees and tax incentives to promote market mechanisms that would increase source reduction, and (3) mandatory standards and regulations governing consumption of products or materials (Marcin et al., 1994). In the study reported here, we analyzed the first two types of strategies, excluding tax incentives, and estimated their potential long-term effectiveness and impact on pulp and paper markets.

We assumed that effectiveness could be measured in terms of reduction in levels of paper and board consumption and production, and thus pulpwood supply, and in terms of reduction in the wastepaper disposal burden. Other potential long-term effects included changes in commodity prices and changes in paper recovery and recycling. In addition, changes in producer and consumer surplus were used as a measure of the overall impact on social welfare.

NAPAP Model

The NAPAP Model provided the framework for our analysis. This is a dynamic, spatial equilibrium economic model that simulates U.S. and Canadian historical trends in paper and paperboard consumption and production, use of pulpwood, and recycled fiber and production technology from the mid-1980s to the present. It projects these trends into the future based on projected changes in supply and demand factors, technology, costs, and other market assumptions.

The NAPAP Model was developed through a cooperative effort involving researchers at the Forest Products Laboratory, the Department of Forestry of the University of Wisconsin–Madison, and the Policy and Economics Directorate of Forestry Canada. The model was used to make long-term projections of fiber use in the U.S. (and Canadian) pulp and paper industry in support of the 1993 RPA Assessment Update by the USDA Forest Service (Ince, 1994; USDA, 1994).

The NAPAP Model is based on PELPS—a price-endogenous linear programming system for modeling economic sectors (Zhang et al., 1993). It consists of a linear programming routine that simulates—for all pulp, paper, and paperboard commodities—regional demand and supply functions, manufacturing activities and costs, and transportation costs, and solves for a spatial equilibrium. Demand and supply functions include export demand and import supply for specified commodities and trade regions. The solution for each year in the projection period consists of a set of regional equilibrium prices, costs, and quantities for all commodities in a given year. The solution covers U.S. and Canadian regional supply, demand and production, and trade with export and import regions.

The equilibrium solution maximizes an objective function that consists of the producer and consumer surplus (the area under all the demand curves minus the area under all the supply
curves) for all commodities produced, consumed, and traded, across all regions, minus all transportation and manufacturing costs. This is defined as the net social surplus (Z). It is calculated in aggregate form for the United States, Canada, and all trade sectors combined; i.e., a separate net social surplus for the United States is not calculated. The objective function representing the net social surplus is specified as follows (Zhang et al., 1993):

Max \( Z = Z_d - Z_s - Z_t - Z_m \)

where
\[ Z_d = \sum_k \sum_i \int P_{ik}(D_{ik})dD_{ik}, \] area under the demand curves,
\[ Z_s = \sum_k \sum_i \int P_{ik}(S_{ik})dS_{ik}, \] area under the supply curves,
\[ Z_d - Z_s = \text{total producer and consumer surplus}, \]
\[ Z_t = \sum_k \sum_i \sum_j T_{ijk}d_{ijk}, \] transportation costs,
\[ Z_m = \sum_k \sum_i \sum_p \sum_x Y_{ikpx}d_{ikpx}, \] manufacturing costs,

i and j = regions,

k = commodities,
p = manufacturing processes, and

k = input mixes per process.

Demand and supply functions use the following general Cobb–Douglas form:

\[ Q_{i,t} = P_{i,t}^{b_1} X_{1_{i,t}}^{b_2} X_{2_{i,t}}^{b_3} X_{3_{i,t}}^{b_4} Q_{i,t-1}^{b_5}, \] for region i, in year t,

\[ Q_{i,t} = \text{quantity demanded or supplied, } D_{ik,t} \text{ or } S_{ik,t}, \text{ respectively}, \]

\[ P_{i,t} = \text{own price of commodity, in 1986 constant U.S. dollars,} \]

\[ X_{1_{i,t}} X_{2_{i,t}} X_{3_{i,t}} = \text{optional shifter variables, and} \]

\[ Q_{i,t-1} = \text{lagged quantity demanded or supplied, } D_{ik,t-1} \text{ or } S_{ik,t-1}, \text{ respectively} \]

(optional variable).

These functions are estimated in log–log linear form. In this linear form, the coefficients—b1, b2, b3, b4, b5—are the elasticities for the corresponding variables.

There is an estimated demand and supply equation in the model for each commodity and region. The equations are represented by the elasticities, the base-year (1986) quantity and price, and projected growth rates for any shifter variables. To calculate the areas under the demand and supply curves for the objective function, within a linear programming system, the model uses stepwise approximations to the areas (Zhang et al. 1993).

To make projections into the future, a recursive routine updates parameters in the linear program with the previous solution values and exogenous changes, and calculates a similar
solution in each subsequent year during the specified projection period, 1987–2040. The years for which actual data are available (1986–1989 or 1990) serve as a calibration period for model assumptions.

**U.S. CONSUMPTION COMPARED TO CONSUMPTION IN OTHER COUNTRIES**

Paper and paperboard consumption in the United States was compared to consumption in Canada, Japan, former West Germany, the United Kingdom, and Sweden. To make the comparison among countries more meaningful, we looked at consumption on a per capita basis. The United States has the highest level of consumption of paper and paperboard in the world—in total and by commodity. On a per capita basis, total consumption in the United States was more than 300 kg per person in 1990. Total consumption in Sweden was closest to U.S. consumption, followed by Canada, Japan, former West Germany, and the United Kingdom. Although relatively flat in recent years, consumption in the United States, as in the other countries, has been slowly increasing since the recession in the early 1980s (Figure 1).

![Per capita consumption of paper and board, 1979-1990.](image)

Increases in U.S. consumption of paper and board have been associated with increases in gross national product (GNP) or the general growth of the national economy. With continued growth of the U.S. economy, we can expect a general tendency for increased consumption of paper and board commodities, as in the past. The same is assumed for the other countries.
Table 1. Difference in per capita consumption between United States and selected foreign countries (%)

<table>
<thead>
<tr>
<th>Paper type</th>
<th>1990 Actual</th>
<th>2010</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newsprint</td>
<td>-12</td>
<td>-14</td>
<td>-16</td>
</tr>
<tr>
<td>Printing and writing</td>
<td>-18</td>
<td>(*)</td>
<td>(*)</td>
</tr>
<tr>
<td>Tissue and sanitary</td>
<td>-28</td>
<td>-11</td>
<td>-9</td>
</tr>
<tr>
<td>Wrapping and packaging</td>
<td>-34</td>
<td>-24</td>
<td>-23</td>
</tr>
<tr>
<td>paper and board</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total paper and board</td>
<td>-26</td>
<td>-15</td>
<td>-11</td>
</tr>
</tbody>
</table>

*No difference in the year 2005.

We assumed that the gap in consumption between the United States and other countries constitutes a potential for future reductions in overall U.S. consumption; it measures what could reasonably be expected as future reductions in the United States without a major adjustment in the standard of living. However, because consumption is expected to continue to grow in the future as national income grows, the potential reduction in consumption will probably occur as decreases in the growth rate rather than in absolute growth. Thus, demand adjustments in this study were made in terms of reductions in the annual rate of growth.

To estimate a feasible overall target goal for source reduction in the United States, we projected the average per capita consumption for the group of selected industrialized countries for the period 1991–2040 based on historical trends in each country during the period 1970–1990. This was a trend projection based on a correlation of past consumption with time. Neither this projection (called Other Countries in the figures) nor the Base Scenario included any assumptions about future increased source reduction and recycling efforts over historical and recent trends.

The difference in the projected levels represents the expected gap in per capita consumption between the United States and the average for the group of selected countries based on historical and recent trends. This gap is shown in Table 1, for selected commodities, as the percentage of difference in consumption relative to U.S. levels. The assumed potential for long-term source reduction in the United States was based on the 11% gap projected for all paper and board commodities by the year 2040. By rounding to the nearest 10th, the assumption was made that U.S. per capita consumption of paper and board could decrease by 10% by the year 2040.

ALTERNATIVE POLICY STRATEGIES

Scenario A

Scenario A represents demand-side strategies for source reduction. These would involve policies such as those promoting education programs and those encouraging voluntary efforts to
reduce the use of paper and board, private initiatives to reduce paper waste in production and consumption, and voluntary compliance with guidelines and suggestions. This type of policy strategy would affect consumption patterns over time, resulting in negative shifts in demand. It was assumed to cause little disruption in markets by working gradually to reduce demand for paper and board.

Based in part on the comparisons with consumption in other countries described earlier, annual rates of growth in demand for individual paper and board commodities in the NAPAP Model were reduced gradually and uniformly such that a 10% negative shift in demand functions occurred over the period from 1995 to 2040. An annual shift in U.S. demand was imposed exogenously in the NAPAP Model over the period from 1995 to 2040.

**Scenario B**

Scenario B represents supply-side strategies for source reduction. These would involve policies such as the use of advance disposal fees to help "internalize" the cost of waste disposal for various commodities. Such policies would constitute a more direct market intervention that would be reflected in higher production costs, resulting in negative shifts in supply that would in turn be reflected eventually in higher prices and lower consumption of paper and paperboard. As an example, Florida has already implemented an advance disposal fee program for containers made of glass, plastic, plastic-coated paper, and various metals. Unless a given sustained recovery rate or sustained recycled material content rate is met, a fee is charged for each container sold or otherwise provided to a dealer in the state (State of Florida Legislature, 1993).

The cost of collection and disposal of waste has typically been borne by the community in which the waste is generated through taxes, fees, or negative externalities. Often, there has been a lack of economic incentive for either the firm that produces the products that end up as waste, or the consumer who uses those products, to recover them effectively for recycling. Charging commodity producers a front-end fee based on end-product disposal cost would also raise the cost of end-products. It would make source reduction in the production process an attractive alternative. In addition, if the cost is passed on to the consumer through higher prices, quantity demanded (consumption) would decrease given a negative price elasticity of demand.

In 1991, the Tellus Institute of Boston estimated the costs of disposal for various paper and paperboard products for the California Integrated Waste Management Board (Tellus Institute, 1991). The estimated disposal costs, in dollars/ton, are as follows:

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Cost($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newspaper</td>
<td>82.24</td>
</tr>
<tr>
<td>Corrugated containers</td>
<td>118.16</td>
</tr>
<tr>
<td>High grade paper</td>
<td>81.12</td>
</tr>
<tr>
<td>Mixed paper</td>
<td>124.00</td>
</tr>
<tr>
<td>Other paper</td>
<td>130.04</td>
</tr>
</tbody>
</table>

For Scenario B, it was assumed that such disposal costs could be charged to firms as production fees, thus raising the cost of production of the various grades of paper. As stated
earlier, this would result in higher product prices in proportion to the disposal fees, which would have a negative impact on demand quantities through negative price elasticities.

In the NAPAP Model, manufacturing costs of relevant paper commodities were increased based on the above disposal cost estimates. It was assumed that disposal fees would be imposed gradually and passed on to the consumer over a 10-year period, starting in 1995. Thus, an annual shift in manufacturing cost was imposed exogenously in the NAPAP Model over the period 1995 to 2005.

RESULTS

Projections for the Base Scenario were compared to projections for Scenario A and Scenario B. In addition, projections of U.S. per capita consumption were compared to historical data and projections for the selected group of other industrialized countries (Figures 2–4).

U.S. Consumption of Paper and Board

U.S. consumption of paper and paperboard products was projected to continue to rise, from about 80 million tons in 1992 to about 140 million tons by 2040. Compared to the Base Scenario, Scenario A provides a gradual reduction in consumption of about 9% by 2040 whereas Scenario B has a more immediate impact in the first decade of about 9% and an overall decrease of 11% by 2040.

On a per capita basis, Scenario B results in a leveling off of consumption at about 300 kg until 2010 before rising again. In the Base Scenario, per capita consumption continues to rise to about 430 kg by 2040. In Scenario A, growth in per capita consumption slows gradually so that the level of consumption approaches that in Scenario B by 2040. Results are the same as those for total consumption—a 9% reduction in Scenario A relative to the Base Scenario and an 11% reduction in Scenario B.

Both scenarios reduce the growth in U.S. consumption of paper and board, bringing it close to estimated future consumption in the selected group of other industrialized countries. Scenario B achieves this sooner and somewhat more completely (Figure 2). As stated earlier, projected future consumption in the group of countries used for comparison is based on historical and recent trends. To the extent that future programs and efforts at source reduction in these countries would increase over past trends, the resulting gap in projections would be larger.

Projections of per capita consumption for individual commodities also show reductions, though the extent of reduction varies. Scenario A is more effective at bringing U.S. consumption of newsprint (Figure 3) and tissue and sanitary papers very close to estimated future levels in the group of other countries. On the other hand, Scenario B seems more effective in reducing U.S. consumption of wrapping and packaging paper and board (Figure 4), although a consumption gap would persist.
Figure 2. Per capita consumption of paper and board in the United States (1970-1989, historical trend; 1990-2040, projection).

Figure 3. Per capita consumption of newsprint in the United States (1970-1989, historical trend; 1990-2040, projection).
Figure 4. Per capita consumption of wrapping and packaging paper and board in the United States (1970-1989, historical trend; 1990-2040, projection).

One way that the projected gap for wrapping and packaging paper and board may be narrowed is if future basis weights for U.S. commodities would decrease. Typically, as in this study, consumption of commodities is measured on a tonnage weight basis. For some commodities, the unit weight (weight per unit volume) for a given commodity in the United States is different than that in some European countries. For packaging paperboard, the unit weight in the United States is higher. If the unit weight in the United States were to decrease gradually, then total weight of consumption would decrease even though the volume may not decrease.

**Paper Recovery and Recycling**

Recovered wastepaper is collected and recycled for utilization by the paper industry as well as for other purposes such as cellulose insulation, animal bedding, composite products, and wastepaper export. The rate of wastepaper recovery has risen rapidly—from about 25% in 1980 to about 40% in 1993. The paper industry has recently announced a goal of 50% paper recovery by the year 2000 (Marcin et al., 1994). All three scenarios project further increases in wastepaper recovery. Projections in Scenarios A and B show slightly greater and similar recovery rates by 2040—more than 60% compared to about 58% in the Base Scenario (Figure 5).

The wastepaper disposal burden is the amount of paper produced and consumed that has not been recovered for recycling or other uses. It is therefore a measure of the current or potential disposal problem for communities and society. Projections in the Base Scenario show a dramatic drop in the disposal burden by the year 2000 (Figure 6) as a result of ongoing and expected community efforts and government programs promoting recycling.
Figure 5. Recovery rate for recyclable paper in the United States. (Recovery rate = ratio of recyclable paper collected to total supply.)

Figure 6. Gross wastepaper disposal burden of the United States (paper and board consumption minus recyclable paper recovery).
In both Scenarios A and B, paper and board consumption is projected to have a slower growth and the wastepaper recovery rate is projected to increase above the rate in the Base Scenario. Therefore, the gross wastepaper disposal burden under both alternative policy strategies is projected to decline, especially in Scenario B.

**Pulpwood Supply and Fiber Prices**

Total pulpwood supply—the amount harvested or produced (in the case of residues)—increased from almost 50 million cubic meters in 1950 to almost 200 million cubic meters in 1990. Trends have paralleled those of paper and board consumption and production. Thus, just as with consumption and production (Figure 7), further steady increases are projected for all scenarios, though rates of growth vary somewhat by Scenario, resulting in slightly lower levels in Scenarios A and B (Figure 8).

![Chart showing pulpwood supply and fiber prices](chart.png)

**Figure 7.** Production of paper and board in the United States.
Figure 8. Total U.S. pulpwood supply to markets (includes mill residues).

Compared to the Base Scenario, total pulpwood consumption is projected to decrease by 4% for Scenario A and 6% for Scenario B by 2040. This is a smaller decrease relative to the Base Scenario than for paper and board consumption and production, which decrease 9% and 11%, respectively. This discrepancy in total pulpwood consumption may be due to lower pulpwood prices relative to the Base Scenario and relative to recovered paper prices early in the projection period. Such relative price trends would result in greater use of pulpwood fiber relative to recycled fiber before pulpwood prices recover and increase later in the projection period. Indeed, real prices for recovered paper are projected to increase dramatically by the year 2000 for all regions and in all scenarios because of increased demand for recovered paper, especially for export, and ultimately limited supplies since growth in production and consumption declines.

**Net Social Surplus**

The net social surplus that constitutes the objective function in the linear programming problem was calculated and maximized in each equilibrium period as an aggregate over all commodities, sectors (consumption, production, supply, and trade) and regions included in the NAPAP Model. Results show that projected net social surplus continually increases in all three scenarios, but at a decreasing rate in Scenarios A and B after 1995, when the adjustments in demand growth (Scenario A) and product cost (Scenario B) begin (Figure 9).
In 1986, the base year for the model, the net social surplus is the same in all three scenarios because all assumptions are the same during this period. After 1995, when the adjustments begin, the net social surplus in Scenarios A and B begins to diverge gradually from the Base Scenario—it decreases, slightly more for Scenario B than for Scenario A.

These decreases from the Base Scenario correspond roughly to the decreases in paper and board consumption and production in the United States. The decreases could result from lower consumer and/or producer surplus, higher transportation costs caused by larger quantities transported (unit costs are assumed constant), or higher manufacturing costs resulting from changes to more costly processes (manufacturing costs are assumed constant for each process). Since the net social surplus is calculated in a highly aggregated form, individual sector or regional impacts cannot be determined.

CONCLUSIONS

In this study, we analyzed the effects of two types of policy strategies for achieving greater source reduction in U.S. pulp and paper markets. Results show that both demand-side and supply-side strategies would result in source reduction by decreasing the rate of growth in paper and board consumption and in pulpwood supply, and by increasing the rate of recovery for recyclable paper. A strategy based on policies that affect production and result in shifts in supply, such as charging advance disposal fees for paper and board produced, may result in a greater incentive to conserve paper and collect it for recycling. It could also raise revenues for education, promoting
recycling and paying for waste disposal. However, such a strategy could be controversial and
difficult to implement. Policies that result in shifts in demand, such as promoting voluntary action
and education, are already in place and, with additional encouragement and support, could
achieve the same result. A combination of these two types of strategies may achieve the best
results.

According to this study and its assumptions, the positive benefits of the policy strategies
may be considered rather small and long in coming relative to the effort and funding required.
After all, it would take several decades to gain a small (6% or 7%) reduction in pulpwood fiber
needs. And the net social benefits, as measured by the net social surplus in all U.S. and Canadian
pulp and paper markets, would tend to decrease over the long term.

It would be interesting to analyze changes in net social surplus in the United States and
Canada separately, and/or in demand and supply markets separately, and/or by individual region.
This is not possible at present because the calculation of net social surplus in NAPAP Model is in
aggregate form. However, with some changes in the computer algorithm and code for handling
the individual pieces of the equilibrium solution, calculation of producer and consumer surplus
and of disaggregated net social surplus would be possible.

The NAPAP Model could be used to analyze policies and consequences of externalities.
The PELPS modeling framework has the potential to include relevant externalities, especially if
they can be represented as commodity prices, manufacturing or transportation costs, or process
input requirements. In this study, the social and environmental costs of wastepaper disposal and of
increasing carbon gas emissions are externalities. The disposal fee modeled in Scenario B
represents, in part, the externality cost associated with the disposal of wastepaper. This externality
cost was internalized in the model as an added manufacturing cost resulting in an increased price
for the commodity and decreased consumption.

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