ECONOMIC TRADEOFFS OF STREAMSIDE MANAGEMENT ZONES

Jon Caulfield, Auburn University School of Forestry, Auburn, AL
John Welker, Mead Corporation, Columbus, GA
Ralph Meldahl, Auburn University School of Forestry, Auburn, AL

INTRODUCTION

The impact of environmental protection practices on the profitability of timber growing concerns both industrial and non-industrial forest owners. Whether increased levels of protection are imposed by government edict or voluntary, questions arise over the type and magnitude of costs and benefits associated with low impact forest management practices.

In the South, environmental protection measures directed toward forest lands have been put forth at the state level, in the form of "best management practices" (BMPs). BMPs are modified harvesting and roadbuilding practices which have as objectives reductions in sedimentation and soil compaction. In most southern states, BMPs are voluntary. But a number of states are currently considering various regulations requiring BMPs on private lands. A partial list of BMPs recommended by state agencies includes installation of culverts, water bars, proper road/landing/skid trail placement and streamside management zones (SMZs) (Alabama Forestry Commission 1991).

A streamside management zone is a non-cut or partially cut buffer strip of trees adjacent to a stream. The purposes of SMZs are to reduce sedimentation from harvesting activities, maintain wildlife habitat, and aid in regulating stream water temperatures (Georgia Forestry Commission 1990).

There is considerable variability in what constitutes an SMZ in practice. Most state guidelines recognize this, and stress that proper SMZ establishment depends on on-site evaluation. In Georgia, for example, suggested minimum SMZ widths range from 20' in the lower coastal plain to 80' on either side of piedmont and mountain streamcourses (Georgia Forestry Commission 1990).

Several authors have examined the economics of BMPs. Dissmeyer (1986) presents a general discussion of the economic impacts of erosion and sedimentation on forest lands, in terms of site productivity lost due to erosion.

Ellefson and Miles (1985) examined the costs to a timber purchaser of implementing seven different BMPs on a case-study tract in the midwest. In that study, net revenue was reduced by
60%. An earlier study by Ellefson and and Weible (1980) examined
the impact of various BMPs and showed that depending on the
combination of BMPs applied, logging profits would be reduced
anywhere from 1% to 53%.

Dykstra and Froehlich (1976) studied the costs of three
different stream protection alternatives, including SMZs, in
western Oregon. Their study showed no clear distinction as to
which protection alternative was most cost-effective.

Hickman and Jackson (1979) employed linear programming to
determine potential economic losses in a Texas county if timber
management practices were constrained by limits on soil erosion
rates. Compared to the unconstrained case, economic losses
ranging from 7% and 77%, were estimated. Losses increased with
increasing restrictions on erosion rates.

Barringer (1987) estimated the costs that would be incurred
on a 30-acre Oregon timber sale from designating an SMZ. In that
instance, the owner would have left 24% of the value of the trees
in the SMZ.

Until recently, most researchers examined BMPs for forestry
operations in midwestern or western states. A new study by
Lickwar et al. (1992) provides an economic analysis of 22 timber
harvests in Alabama, Florida and Georgia, to estimate the
marginal costs of implementing 6 different BMPs recommended or
required in each state. The cost of implementing BMPs ranged
from 2.9% to 5.1% of gross timber sale revenue.

Several features are common to most studies examining the
economics of BMPs. Usually, a case study approach is employed.
The type of case ranges from a small tract of land involved in a
timber sale (Barringer 1987), a county (Hickman and Jackson 1979)
or a group of tracts spread over several physiographic regions
(Lickwar et al. 1992).

A second feature common to most existing research is that
the costs of several different BMPs are evaluated. These may be
limited to different types of harvesting alternatives, as
described in Dykstra and Froehlich (1976), or encompass a wide
array of harvesting, roadbuilding and post-harvest practices, as
in Lickwar et al. (1992).

Finally, while several studies consider the opportunity
costs of lost timber revenue from imposing BMPs, most do so under
the implicit assumption that these costs accrue only to the
current crop of timber. One exception is the Hickman and Jackson
study, which assumes an infinite time horizon.

This study is in one respect similar to existing work, but
differs in several other ways. A case-study approach is employed
to estimate the cost of implementing BMPs, as have previous studies. But the type of case considered, that of an actual industrial forest, differs from other research.

This study is also more narrowly defined than previous work because it examines only one type of BMP, the establishment of streamside management zones. Finally, the cost of establishing SMZs is examined from the standpoint of a continuing forestry enterprise, rather than a single timber harvest.

The study objective was to estimate the potential opportunity costs of SMZs on an industrial forest ownership in the Georgia piedmont, by calculating the dollar value of these costs. This was measured by calculating the present value of the timber revenue obtainable from the ownership over an infinite time horizon, and reducing that value by the potential revenue that would be lost from SMZ set-asides.

BACKGROUND

Ownership Description and Objectives

The forest analyzed is managed by Mead Corporation, and consists of 51,266 acres in the Georgia piedmont. This is a sub-unit of the company's overall woodlands operation in Georgia and Alabama. The forest is comprised of a number of non-contiguous tracts of timber, in an unregulated condition. There are 331 identifiable, mapped, timber stands on the ownership, which include several distinct timber types. The ownership represents a typical cross-section of piedmont forest conditions, ranging from bottomland hardwoods to upland pine sites.

The timber classifications employed by Mead are:

1. Natural pine (upland pine sites)
2. Pine plantation
3. Bottomland hardwood
4. Cove hardwood
5. Upland hardwood

These are managerial rather than ecological classifications, but are based on the predominant ecological class of a specific timber type in a stand. For example, an entire stand could be categorized as bottomland hardwood if 70% of that stand were of that timber type, even if the other 30% were cove hardwood.

The total forest area is broken down into timber types as follows:
Natural pine/pine plantation: 39,140 76
Bottomland Hardwood: 5160 10
Cove Hardwood: 6457 13
Upland Hardwood: 509 1
Total: 51,266 100

Individual timber stands range in age from 0 to 70 years, with the oldest age classes in the hardwood stand types. The average age of all hardwood stands is 41 years, versus 16 years for pine. Approximately 30% of the natural pine was felled since 1984, and regenerated to plantation.

Site indexes were measured to the nearest 5 feet on pine sites and into somewhat more broadly on hardwood sites.

The primary ownership objective for the forest is to maximize the economic returns from growing timber in a manner consistent with environmentally sound management practices. It was assumed that all timber would be cut as pulpwood. This reflects first, some limitations that were encountered with the data, discussed later. It also reflects Mead's role as primarily a paper manufacturer.

Establishment of Streamside Management Zones

Streamside management zones were established by company foresters in stands in the bottomland, cove and upland hardwood types. SMZs are areas in which either no cutting takes place when the adjacent stand is harvested or where thinnings may be permitted.

Company foresters try to establish SMZs with a minimum width of 50' on each side of a stream. The areas delineated are often substantially wider for several reasons. First, the minimum SMZ widths may not be appropriate when two streams meet one another at an acute angle. In such instances it often is operationally more convenient to include all the area between the two streams in the SMZ. Physiographic conditions can also cause SMZ widths to vary.

There is considerable diversity in SMZ size. These range from 3.4 to 273.7 acres, and average 33.4 acres. The areas in SMZs for each timber type appears in table 1.

METHODS

To determine the economic impact of SMZs on profitability, estimates of timber volumes and values were generated for each
stand of trees. Total forest value was obtained by summing individual stand values. The value of both non-SMZ and SMZ acres were included in the total. The impact of setting aside SMZs was defined as the potential timber revenue lost from these acres.

Value was defined as the sum of current stand values, plus the net discounted value of a perpetual series of even-aged stands on the site, following the current stand. This is simply Faustmann's LEV criterion (1849). But some adjustments had to be made.

Table 1. Areas in Streamside Management Zones in Each Timber Type

<table>
<thead>
<tr>
<th>Timber Type</th>
<th>Total Acres</th>
<th>Acres in SMZ</th>
<th>Percent SMZ</th>
<th>Mean SMZ Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planted and Natural Pine</td>
<td>39,140</td>
<td>0</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>Bottomland Hdw.</td>
<td>5160</td>
<td>1571</td>
<td>30.4</td>
<td>27.1</td>
</tr>
<tr>
<td>Cove Hdw.</td>
<td>6457</td>
<td>2522</td>
<td>39.1</td>
<td>44.3</td>
</tr>
<tr>
<td>Upland Hdw.</td>
<td>509</td>
<td>112</td>
<td>14.2</td>
<td>14.2</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>51,266</strong></td>
<td><strong>4205</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A 30-year rotation was assumed for all stands. However, existing stands range in age from 0 to 70 years old. Therefore, for existing stands less than 30 years old, value is defined as the projected value at age 30 discounted to the present, plus the discounted value of all future rotations. For stands presently 30 years or older, value consists of the current stumpage value of standing timber plus the discounted value of all future rotations on the site.

The Southeastern Twigs (SETWIGS) growth and yield model (Meldahl et al. 1987) was employed to predict standing and future timber volumes for existing natural stands. SETWIGS can be used to predict growth for stands of mixed-pine hardwood, natural pine and pine plantations. Inputs to the model require a tree list for the stand, age, site index, and a projection period. These were supplied from cruise data. To predict the yields of existing and future pine plantations on the forest we employed the NCSU Loblolly pine growth and yield simulator (Hafley and Smith 1989).

To predict volumes for hardwood areas regenerated to hardwood following clearcutting, growth and yield relationships developed by the NC State Hardwood Cooperative, as adapted by Mead for local conditions, were used. These project pulpwood volumes for bottomland, cove and upland hardwood stands in terms
Determining the opportunity costs of SMZs is complicated by the fact that value loss depends on what a site would be used for if it were not placed in an SMZ. For the 39,140 acres of existing natural pine stands and pine plantations this was straightforward. There were no SMZs designated in any of the pine stands, so losses from SMZs were not an issue on these sites. All areas currently in natural pine stands or pine plantation are scheduled to be regenerated to pine plantation following harvest. While predicting stand yield and value is seldom a precise exercise, it was most easily carried out on these sites.

Estimating volume and value is more difficult on hardwood sites. Many of these areas can be converted to pine plantation, or naturally regenerated back to hardwood following clearcutting. Each alternative has different associated revenues and costs. Therefore, measuring the cost of setting aside SMZs requires that the total value of the entire forest for timber production first be determined. If there are several potential management alternatives available, several costs can also be calculated. Therefore, the revenue "loss" from SMZ sites depends on how the site would be managed if it were not an SMZ.

To account for the different possible regeneration alternatives associated with hardwood stands, several scenarios were considered. First, hypothetical maximum and minimum timber production values for the entire forest were estimated. More realistic management scenarios were then introduced, including the one that the company currently employs. The scenarios evaluated were:

1. The hypothetical maximum production value (MAX scenario) of the forest was determined by assuming that all stands, when cut, were converted to pine plantation, regardless of whether they were initially in the pine or hardwood timber type. This provided a hypothetical maximum because the per-acre LEV from pine plantations was higher than from other management systems. The total value of current stands, plus that of all future stands from each initial forest type were summed, to obtain the maximum value. The opportunity cost of SMZs were defined as production value lost from setting aside those acres, assuming that they would otherwise be regenerated to pine plantation.

2. The hypothetical minimum production value (MIN scenario) of the forest was calculated by assuming that all acres in the hardwood forest type were left uncut. Natural pine stands were assumed to be regenerated to pine plantations, as were existing pine plantations. This scenario provides a minimum because it eliminated entirely the production value of the hardwood forest.
3. The current situation (CURRENT PRACTICE, or CP scenario). This reflects the current company management practice. As in scenarios (1) and (2), all pine sites are regenerated to pine plantations. The regeneration of non-SMZ hardwood sites is split between pine plantation and what Mead calls "hardwood clearcut management." (HDWCC). HDWCC management is employed in those hardwood stands, or portions of hardwood stands, not considered suitable for conversion to pine. Areas designated for HDWCC management are clearcut, residual non-merchantable stems felled, and naturally regenerated to hardwood. Other hardwood sites, typically uplands or ridges, are regenerated to pine. The division of hardwood sites between areas suitable for pine conversion and hardwood clearcut management is made on the ground by company foresters. The timber value loss from the SMZ areas is made under the assumption that if the SMZs were regenerated, hardwood clearcut management would be employed on those acres.

4. A fourth scenario assumes that no hardwood stand would be converted to pine plantation (HARDWOOD scenario). Instead, all hardwood stands would be regenerated back to hardwood. Pine stands will be as in the situations described above. The idea was to examine the cost of a situation that is more preservationist of the hardwood timber type, but that does not rule out hardwood production in non-SMZ areas, as in the MIN scenario.

5. The final scenario assumes that rather than placing SMZs completely off limits to harvesting, these areas are periodically thinned (THINNING scenario). At age 30, 40% of merchantable volume, or a minimum of 10 cords per acre, whichever is greater, is removed. The stand is then thinned every 30 years thereafter, in perpetuity. In each thinning following the first one, the mean annual increment produced by the stand over the 30-year period is removed. The economic impact of thinning is introduced into the MAX, CP and HARDWOOD scenarios, and changes the names for each of these to: MAX/THIN, CP/THIN AND HARDWOOD/THIN. The MIN scenario was not evaluated in conjunction with thinning.

The economic parameters used in the analysis represent average values obtained from the literature and an informal survey of woodlands managers in Georgia and Alabama. These are:

a. 4% real discount rate
c. Regeneration and management costs:
   i. Site preparation, seedling and planting costs of $210/acre when converting hardwood to pine plantation
   ii. Site preparation, seedling and planting costs of
$150/acre when regenerating pine plantation or natural pine to pine plantation

iii. Management costs of $1/acre in year 1 and $11/acre in year 3 of the life of pine plantations

iv. Felling residuals in hardwood clearcut management costs $10/acre.

v. Pine plantations were established with 726 trees/acre. No thinnings or intermediate cutting carried out

vi. Rotation ages for all harvestable stands was 30 years

d. Analysis is on a before-tax basis

RESULTS

Under the assumption that all sites would be placed under pine plantation management (MAX scenario), the timber production value for the entire forest was calculated (table 2). It should be stressed that this represents a hypothetical maximum value because some hardwood sites may not be appropriate candidates for conversion without expensive site preparation. This case is included not because it necessarily is the most realistic in terms of the management strategy that may be employed, but because it brackets the upper limit of timber production value for the forest.

The timber production value calculated for the MAX scenario is $15.5 million. This value is probably conservative because it assumes that all timber is cut as pulp. If sawtimber were merchandised, the figure would be higher because there are significant sawtimber volumes in many hardwood stands. Although SETWIGS projects gross sawtimber volumes, it does so only on the basis of tree diameter. Because merchantable sawtimber volume is very sensitive to tree quality in hardwoods, which SETWIGS does not account for, the potential for sawtimber production is omitted here.

To account for the value loss from designating SMZs, the total production value of non-SMZ hardwood stands was calculated, and deducted from the total value of all hardwood stands (table 2). The cost of $2.24 million represents 14.4% of the total production value of the forest, or 35% of the value of all hardwood stands, assuming that the hardwood stands would be converted to pine.

The minimum production value for the forest (MIN scenario) is simply the total value of all existing pine stands, assuming they are regenerated to pine plantation (table 2). This establishes a hypothetical floor forest production value. Put another way, if all hardwood stands remain uncut, the loss of these stands from the MAX scenario implies a maximum productivity loss of 40.5% of total forest value and 100% of hardwood value.
In the Current Practice scenario (CP scenario), all pine stands are regenerated to pine plantation. Non-SMZ hardwood stands are either regenerated to pine plantation on appropriate sites, or managed using hardwood clearcut management on other areas. SMZs remain uncut. However, the value of timber on SMZ lands is calculated under the assumption that if cut, they would have been managed using hardwood clearcut management.

In this case, setting aside SMZs results in a loss of $1.69 million, or 11.4% of total forest production value (table 2). This is a loss of 30.3% of the potential value of the hardwood type. Although less than the losses in the MAX scenario, these still represent substantial opportunity costs.

In the HARDWOOD scenario, it is assumed that pine stands remain in pine, as before. But now, HDWCC management is assumed to be employed in all non-SMZ hardwood stands. If SMZ stands were managed, they would be managed in the same manner. The dollar cost of SMZs is identical to the CP scenario (table 2). The $1.69 million represents an 11.5% loss of total timber production value of the forest, or 30.8% of the hardwood type. The percentage losses are very slightly higher than for the CP case.

The dollar costs are identical because the assumption that HDWCC was employed on all acres decreased both total production value of hardwood sites, and production value of non-SMZ sites by the same dollar amount (both were reduced by $84,579). The value of SMZs was identical in each case, however, because HDWCC management was employed in each case.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Forest</th>
<th>Pine</th>
<th>Non-SMZ</th>
<th>SMZ Opportunity</th>
<th>Percent Loss from:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hardwood</td>
<td>Cost</td>
<td>Forest</td>
</tr>
<tr>
<td>MAX</td>
<td>15.559</td>
<td>9.259</td>
<td>4.055</td>
<td>(2.245)</td>
<td>14.4</td>
</tr>
<tr>
<td>MIN</td>
<td>15.559</td>
<td>9.259</td>
<td>(4.055)</td>
<td>(2.245)</td>
<td>40.5</td>
</tr>
<tr>
<td>CP(^5)</td>
<td>14.839</td>
<td>9.259</td>
<td>3.888</td>
<td>(1.692)</td>
<td>11.4</td>
</tr>
<tr>
<td>HARDWOOD</td>
<td>14.754</td>
<td>9.259</td>
<td>3.803</td>
<td>(1.692)</td>
<td>11.5</td>
</tr>
</tbody>
</table>

1 FOREST = PINE + NON-SMZ HARDWOOD + SMZ
2 Parentheses indicate costs, or non-realized values
3 $14.4 = (2.245/15.559) \times 100$
4 $35.6 = (2.245/(2.245+4.055)) \times 100$
5 CP = Current Practice

The economic losses illustrated in table 2 are assumed to occur over an infinite series of rotations. Although these losses
result from timber volumes tied up in SMZ set-asides, it is obviously not worthwhile to calculate volume losses using an infinite time horizon. Instead, table 3 presents volumes and SMZ volume losses for each of the four scenarios from the current stands of timber plus the rotation immediately following the current one.

Volume losses can be substantial, and range from 8.7% of total forest volume in the CP scenario, to 31.5% in the MIN scenario. Percentage volume losses in the hardwood type range from 30.9% to 100%.

Table 3. Forest Volumes and SMZ Volume Losses for Existing Stands Plus Next Rotation, by Forest Type (million cords)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Forest</th>
<th>Pine</th>
<th>Non-SMZ Hardwood</th>
<th>SMZ Volume Losses</th>
<th>Percent Loss From Forest</th>
<th>Hardwood</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAX</td>
<td>2.784</td>
<td>1.908</td>
<td>0.568</td>
<td>(0.308)</td>
<td>11.1² 35.2²</td>
<td></td>
</tr>
<tr>
<td>MIN</td>
<td>2.784</td>
<td>1.908</td>
<td>(0.568)</td>
<td>(0.308)</td>
<td>31.5 100.0</td>
<td></td>
</tr>
<tr>
<td>CP⁴</td>
<td>2.656</td>
<td>1.908</td>
<td>0.517</td>
<td>(0.231)</td>
<td>8.7 30.9</td>
<td></td>
</tr>
<tr>
<td>HARDWOOD</td>
<td>2.559</td>
<td>1.908</td>
<td>0.420</td>
<td>(0.231)</td>
<td>9.0 35.5</td>
<td></td>
</tr>
</tbody>
</table>

¹ Parentheses indicate costs or non-realized values
² 11.1 = (0.308/2.784)x100
³ 35.2 = (0.308/(0.308+0.568))x100
⁴ CP = Current Practice

The THINNING scenario consists of several sub-scenarios. If an SMZ is thinned, the value loss from the SMZ consists of the loss from the uncut timber, plus the loss from all future stands that could be grown on the site, minus the value of the thinned trees. As with the results presented to this point, the value of the future stands depends on how clearcut SMZs would otherwise be regenerated. In the MAX scenario the SMZs would be regenerated to pine. In the CP and HARDWOOD scenarios, they would be regenerated using HDWCC management.

The timber value of the thinned SMZs was estimated at $1,139,035. This includes the value of trees thinned from existing stands, plus the discounted value of future thinnings.

The impact of thinning on the opportunity cost of the SMZs, versus the cases in which no thinning was permitted, is illustrated in table 4. The opportunity costs for the MAX, CP and HARDWOOD scenarios without thinning are presented alongside the costs if thinning is permitted. The decrease in value loss is substantial. Thinning essentially cuts the loss by half for the
MAX scenario, and by two thirds for the CP and HARDWOOD scenarios.

Table 4. SMZ Opportunity Cost for Each Scenario With and Without Thinning ($ million)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Opportunity Cost:</th>
<th>Percent Value Losses From:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+thin</td>
<td>no thin</td>
</tr>
<tr>
<td>MAX</td>
<td>1.105</td>
<td>2.244</td>
</tr>
<tr>
<td>CP(^1)</td>
<td>0.552</td>
<td>1.692</td>
</tr>
<tr>
<td>HARDWOOD</td>
<td>0.552</td>
<td>1.692</td>
</tr>
</tbody>
</table>

\(^1\) CP = Current Practice

Allowing thinning diminished volume losses considerably for the current plus following rotations. Volume losses were 5.8% for the MAX scenario when thinning was permitted (table 5), versus 11.1% when it was not (table 3). Similar reductions in volume losses occurred for the other scenarios.

Table 5. Forest volumes and volume losses for existing stands plus next rotation, by forest type, with thinning permitted in SMZs (million cords)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Forest(^1)</th>
<th>Pine</th>
<th>Non-SMZ</th>
<th>SMZ Vol.(^2)</th>
<th>Thinning Vol.</th>
<th>SMZ Loss(^3)</th>
<th>Percent Loss From:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hardwood</td>
<td></td>
<td></td>
<td></td>
<td>Forest</td>
</tr>
<tr>
<td>MAX+thin</td>
<td>2.784</td>
<td>1.908</td>
<td>0.568</td>
<td>(0.308)</td>
<td>0.147</td>
<td>(0.162)</td>
<td>5.8(^4)</td>
</tr>
<tr>
<td>CP+thin</td>
<td>2.656</td>
<td>1.908</td>
<td>0.517</td>
<td>(0.231)</td>
<td>0.147</td>
<td>(0.085)</td>
<td>3.2</td>
</tr>
<tr>
<td>CP+thin</td>
<td>2.559</td>
<td>1.908</td>
<td>0.420</td>
<td>(0.231)</td>
<td>0.147</td>
<td>(0.085)</td>
<td>3.3</td>
</tr>
</tbody>
</table>

\(^1\) Forest = Pine + Non-Smz Hdwd + SMZ
\(^2\) Numbers in curly brackets indicate partially realized values
\(^3\) Parentheses indicate non-realized values
\(^4\) 5.8 = (0.162/2.784) x 100
\(^5\) 18.5 = (0.162/(0.568+.308)) x 100

Discussion

The opportunity cost of SMZ set asides depends largely on how the SMZ would otherwise be managed. When thinning was not permitted, the cost was highest for the most intensive management system and lowest for the least intensive system. Permitting thinning in the SMZs decreased the opportunity costs for each case.

Although the number of acres set aside for SMZs was a fairly small proportion of the total forest (4205 of 51,266 acres, or
small proportion of the total forest (4205 of 51,266 acres, or 8.2%), the opportunity cost can be substantial. With current stumpage prices, value losses of more than $2.2 million, or 14.4% of the total forest value can be realized for the most intensive management scenario.

Volume losses from SMZ set-asides can also be large. For the existing stands and next rotation, volume losses ranged from a high of 11.1% of total potential volume in the MAX scenario, to as low as 3.3% if thinning is permitted in SMZs. More generally, thinning can apparently play a major role in mitigating value and volume losses. Removing 40% of the merchantable volume at age 30 or later, combined with periodic thinning at 30 year intervals decreased value losses by as much as two-thirds.

Several issues are not addressed in the study, but should be noted. First, the results are strongly influenced by the initial forest condition. The forest examined has a high proportion of young pine plantation, with low per-acre value. This contrasts to the hardwood stands, which, while constituting a minority of the acreage, were mostly stocked with mature trees. As a result, the opportunity cost of SMZ set-asides are high relative to the value of the entire forest.

On the other hand, the assumption that all wood from the forest is sold as pulp means that the opportunity cost of the SMZs is probably understated. It is certainly the case that the total production value calculated for the entire forest is conservative. This is a promising area for further investigation.

Finally, it needs to be recognized that the study calculates only the dollar value loss from SMZ set-asides. But there are additional, less easily quantifiable benefits provided by SMZs. As indicated previously, SMZs provide wildlife habitat, reduce erosion, and aid in regulating stream water temperatures. If these benefits could be calculated in dollar terms, they would likely decrease the opportunity costs estimated here. Further research is needed in this area.
Literture Cited


Timber Mart South. 1991. Volume 16 No. 4. Timber Mart South, Highlands, NC.