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Estimating The Costs Of Water Quality Protection On Private Forest Lands In Georgia

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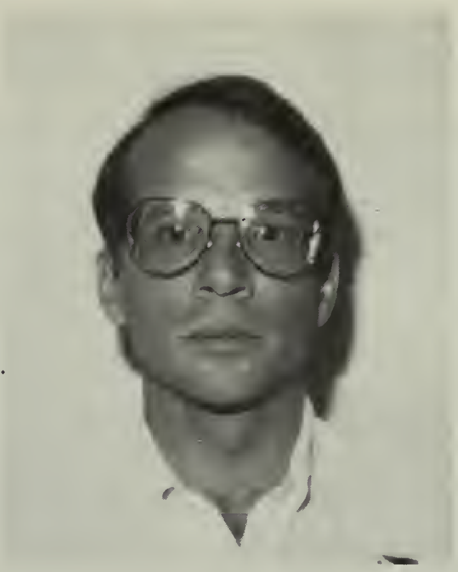

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INTRODUCTION

Despite the recent emphasis on nonpoint source pollution control, little research has been done that quantifies the cost of various types of control practices. The principal purpose of this study was to quantify the operational costs of implementing various forest-related land management practices that may be used to protect water quality in Georgia.

METHODS

Best Management Practice Selection

In order to estimate possible costs of protecting water quality, we selected various best management practices that might be used in Georgia. The practices selected had to be commonly used and practical to implement. Road construction is consistently identified as the primary source of soil erosion from managed forestlands (Sopper 1975, U. S. EPA 1975, Burroughs and King 1985) . Thus, most of the study BMP's chosen addressed erosion control from forest roads. One BMP was related to harvesting near streams. The following best management practices were identified as important means of controlling nonpoint source pollution: 1) Stream Crossings: 2) Broad-Based Dips; 3) Water Bars; 4) Seed, Fertilizer, and Mulch; and 5) Streamside Management Zones.

Three levels of forest practices were used in this study to assess costs of implementing BMPs. The first was termed "Control," and was representative of forest harvesting without use of any BMPs. This level of practice modeled logging without any controls, and did not use any special land management practices to protect the environment.

Two other levels of water quality protection were formulated; these were "BMP Alternative #1" and "BMP Alternative #2." Alternative #1 represented harvesting using the BMP standards recommended by the Georgia Forestry Commission (1988) in its BMP manual. The practices and standards used at each study site were selected based on the site's geographic location, topograhy, soils, and other data. BMP Alternative #2 consisted of a more protective set of practices, which might be required by states under conceivable water quality protection guidelines. The guidelines for BMP Alternative #2 included wider SMZs, only selective cutting in the SMZ, prohibitions on road-building in the SMZ, and improved revegetation of roads and log decks. These three levels of BMP use could be referred to as none (control), recommended (alternative #1), and enhanced (alternative #2).

To accurately determine the effects of different levels of BMP protection on management costs, it was necessary to use actual on-the-ground management cases. To date, most BMPs have addressed water quality protection during forest harvests. Thus this study focused on BMPs and costs applied during harvesting.

Table 1. Description of Study Sites

Region	Harvest Method	Acres	Topography
1. Mountain			
1. Talk Rock #16	Clearcut	664	Steep (9% and up)
2. Talk Rock #34	Clearcut	96	Steep
2. Piedmont			
1. Barnett	Clearcut	112	Moderate (4% to 8%)
2. Lanett #1	Clearcut	77	Moderate
3. Lanett #2	Selection	143	Moderate
4. Watkinsville	Clearcut	38	Moderate
3. Coastal Plain			
1. County	Clearcut	53	Steep
2. Shellman	Clearcut	313	Moderate
3. Baconton*	Clearcut	265	Flat (0% to 3%)
4. Workmore	Clearcut	37	Moderate

* No streams or lakes present

Site Selection

The study examined harvest sites throughout Georgia, from a variety of geographical regions and timber types. Each site had to be accompanied by timber harvest volumes, site maps, location, forest practices used, and existing road structure. Site data were obtained from several sources including state foresters, county foresters, forest products companies, and forest consultants.

Ten harvest sites in Georgia were selected for study on the basis of their geographic location, topography, and the quality of the accompanying data. The characteristics of the sites are summarized in table 1, including the brief name of the topographic region they were located in, the type of timber harvest, the terrain, and broad geographic region. Their locations are shown in figure 1.

Site Engineering

The boundary lines and existing road structure of the selected sites were outlined on United States Geological Survey (USGS) topographic maps. The three levels of forest practices--control, recommended, and enhanced--were then applied to each site. The location of temporary forest roads was particularly important, since their slope and mileage controlled the cost of every selected BMP, except for streamside management zones. For example, the number of broad-based dips and water bars required were calculated by formulas based on percent road slope. The total road surface area determined the amount of seed, fertilizer, and mulch needed.

Road location did not vary much between the three levels of forest practices. The most significant difference was that in the "control" practices, roads were often located in the relatively flat flood plain adjacent to streams. This is typically the approach used by many forest operators. In alternatives #1 and #2, forest roads were not allowed in these floodplains, unless the roads were leading directly to or away from a stream crossing.

While the road location in alternatives #1 and #2 was sometimes different from the control practices' road layout, the total mileage required in each case was usually similar. In only two cases, both in the Georgia mountains, did road mileage increase significantly due to best management practice restrictions.

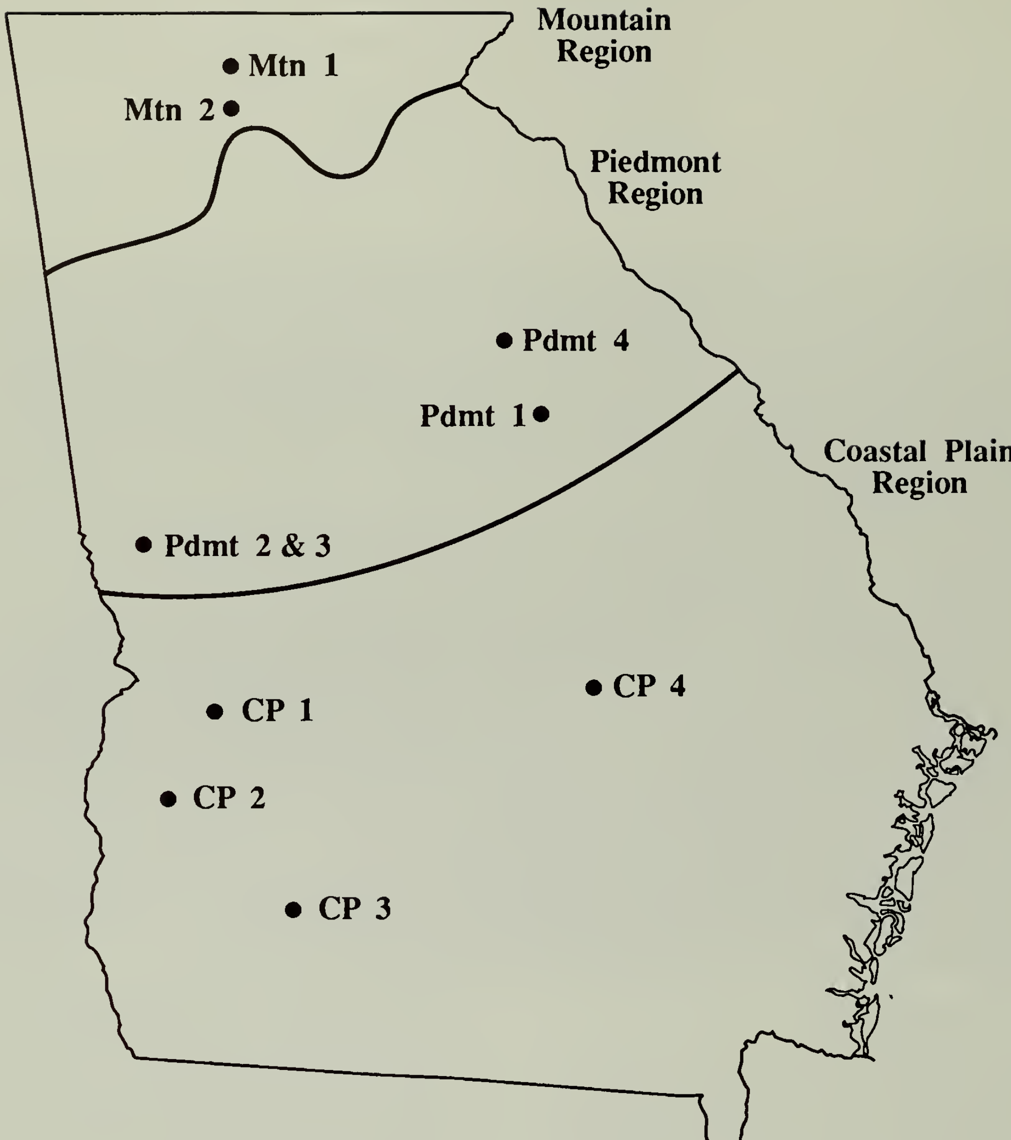

Figure 1. Location of BMP Study Sites in Georgia.

Table 2. Best Management Practice Costs, 1987 dollars

1. Road Construction

Mountains:	$2660 per mile
Piedmont:	$1200 per mile
Coastal Plain:	$ 900 per mile

2. Stream Crossings

Base cost:	$420 per culvert
Culvert pipe:	$ 5.45 per foot 18 inch diameter culvert
	$ 7.10 per foot 24 inch diameter culvert
	$11.07 per foot 36 inch diameter culvert
	$14.52 per foot 48 inch diameter culvert
Gravel:	$14.90 per ton

3. Broad-Based Dips

Cost: $40 each

4. Water Bars

Cost: $20 each

5. Seed, Fertilizer, and Mulch

Seed	
Mountains & Piedmont	
30 lbs/acre Fescue	$ .85 per pound
Coastal Plain	
25 lbs/acre Bahia	$ 1.00 per pound
Fertilizer	
900 lbs/acre 6-12-12	$165 per ton
Mulch	
2.0 tons/acre	$50 per ton

6. Streamside Management Zones

Costs for this practice were from timber value foregone, due to the residual timber requirement. Residual timber requirements as required in Florida's existing best management practices were used as a practice in Alternative #2. These requirements were a function of each site's average timber density, size class, species, and price.

Amount and Cost of Individual Study BMPs

The number or amounts of each of the selected BMPs were estimated for each level of forest practice. These amounts were multiplied by their unit cost to determine a total cost per BMP on each study site. Each case was summarized on a microcomputer spreadsheet, and individual cases were aggregated for regional and state totals. Costs for each practice were derived from several sources. These included a review of the pertinent literature, and consultations with staff from construction companies, forest contractors, forest engineers and faculty from the University of Georgia's School of Forest Resources, and personal study of sites where the selected BMPs were being implemented. Table 2 summarizes the BMP costs per unit used in the study.

RESULTS

Our economic evaluations applied the selected best management practices to the sites where forest harvests actually had occurred. The goal of the study was not only to quantify the costs of these practices, but also to look for trends in BMP costs and to identify practices which could provide substantial water quality protection at an affordable cost.

Table 3. Description of Georgia Sites: Overview of BMP Costs for All Groups of Sites, 1987 Dollars

	Alternative #1 Georgia BMPs	Alternative #2 (Enhanced BMPs)
1. All Sites (10)		
Total $ Cost	$ 39,062	$48,510
% of Gross Stumpage	4.2%	5.2%
$ Per MBF Timber	$ 3.50	$ 4.34
$ Per Acre	$ 21.73	$ 26.98
2. Mountain Sites (2)		
Total $ Cost	$ 25,004	$27,565
% of Gross Stumpage	8.8%	9.7%
$ Per MBF Timber	$ 5.97	$ 6.59
$ Per Acre	$ 32.90	$ 36.27
3. Piedmont Sites (4)		
Total $ Cost	$ 8,300	$10,408
% of Gross Stumpage	3.7%	4.6%
$ Per MBF Timber	$ 3.64	$ 4.56
$ Per Acre	$ 22.43	$ 28.13
4. Coastal Plain Sites (4)		
Total $ Cost	$ 5,756	$10,536
% of Gross Stumpage	1.4%	2.5%
$ Per MBF Timber	$ 1.22	$ 2.24
$ Per Acre	$ 8.62	$ 15.77
5. Steep Sites (3)		
Total $ Cost	$ 26,478	$29,637
% of Gross Stumpage	8.3%	9.3%
$ Per MBF Timber	$ 5.75	$ 6.43
$ Per Acre	$ 32.57	$ 36.45
6. Moderate Sites (6)		
Total $ Cost	$ 11,386	$16,429
% of Gross Stumpage	3.1%	4.5%
$ Per MBF Timber	$ 2.60	$ 3.75
$ Per Acre	$ 15.81	$ 22.82
7. Flat Sites (1)		
Total $ Cost	$ 1,197	$ 2,443
% of Gross Stumpage	0.5%	1.0%
$ Per MBF Timber	$ 0.55	$ 1.12
$ Per Acre	$ 4.52	$ 9.22

Table 4. Description of Georgia Sites: Total Costs for All Sites

Total Acres: 1,798
Total Gross Harvest Revenue: $933,652

BMP Alternative #1 (Recommended)		Cost ($ 1987)	Percent of Gross Stumpage Value
1.	Stream Crossings (none required)	0	0.00
2.	Broad-Based Dips	12,840	1.4
3.	Water Bars	9,160	1.0
4.	Streamside Management Zones	0	0.00
5.	Added Road Costs	3,990	0.4
6.	Seed, Fertilizer, and Mulch	13,072	1.4
	Total	39,062	4.2

*BMP Cost by Timber Volume: $3.50 per MBF

BMP Cost per Acre: $21.73

BMP Alternative #2 (Enhanced)		Cost $ 1987	Percent of Gross Stumpage Price
1.	Stream Crossings (culverts)	160	0.02
2.	Broad-Based Dips	12,720	1.4
3.	Water Bars	9,060	1.0
4.	Streamside Management Zones	3,518	0.4
5.	Added Road Costs	3,990	0.4
6.	Seed, Fertilizer, and Mulch	19,060	2.0
	Total	48,510	5.2

*BMP Cost by Timber Volume: $4.34 per MBF

BMP Cost per Acre: $26.98

* All softwood and hardwood volumes and classes combined

Aggregate BMP Costs

The BMP costs for various combinations of study regions are summarized in Table 3. Table 4 represents the aggregate economic effects of best management practices applied on 1,798 acres of diverse forestland for all sites examined. These sites had an estimated 1987 gross harvested timber value of $933,652, or an average value of $519 per acre, based on Timber Mart-South prices. The average per acre volume of softwood on these lands was 2.9 thousand board feet (MBF, Scribner rule) of sawtimber, and 4.9 cords of pulp. Hardwood volumes averaged 0.67 MBF (Doyle rule) of sawtimber per acre, and 3.0 cords of pulpwood. Regional prices as reported in Timber Mart-South were used for estimating harvest values in different parts of the state.

This average timber volume for hardwood and softwood combined was 6.2 MBF per acre. This value was calculated using nine clearcut sites and one selectively harvested site. For comparison, the 1982 Georgia forest survey estimated that Georgia's forestlands average about 6.2 MBF of hardwood and softwood per acre (Sheffield and Knight 1984). The average timber volumes per acre on the study sites seemed low, but represented an average for all acres cut. Harvested volumes on specific areas were probably greater than these reported aggregate averages. The use of gross, not harvested acreage, tended to lower per acre volumes cut, since probably not every acre was harvested on each tract.

Cost for Selective Harvests

Only one site was selectively harvested, thus its reported timber volume per acre was low. Since costs in the study were calculated as proportions of timber volume or timber value, the BMPs for selective cutting were particularly expensive. One could expect this to occur on all selective cuts where fixed BMP costs are spread over less volume harvested.

Streamside management zones are the only BMP whose cost is reduced by selective harvesting. Since timber is already being left along streams during harvesting, the amount of timber needed to meet the residual timber requirement was reduced considerably. Timber left in the SMZ as a part of normal selective harvesting was not counted as a BMP cost.

DISCUSSION

The costs in table 2 show the expense of full application of each practice. However, the conscientious use of one BMP may eliminate the need for application of other practices. Road retirement with seed, fertilizer, and mulch is an example of one such practice. It has several substantial advantages over other BMPs designed to reduce erosion and sedimentation from temporary forest roads, such as broad-based dips and water bars. Application of these BMPs requires an expensive initial investment in machinery such as a bulldozer, a well-trained and experienced operator (also expensive), a tractor-trailer to bring the bulldozer to the site, and regular maintenance. However, erosion control practices which use seeding have none of these costs. The machinery needed, such as a cyclone seeder, is simple and inexpensive. Though seed, fertilizer, and mulch application is a labor-intensive practice, it requires minimal training and ability to be effectively implemented.

This does not imply that one strictly enforced practice can completely substitute for all other BMPs. Broad-based dips, for example, are a practice which protect water quality during forest harvesting. Road stabilization by seeding is effective, but does not help reduce erosion until after harvesting is over. Both practices are needed at different phases of the harvest to adequately protect water quality.

Stream Crossings

When forest roads intersect with streams the potential for nonpoint source pollution increases, since large amounts of disturbed soil are directly in or adjacent to the stream. However, stream crossing BMPs were often the most inexpensive of all practices. Their aggregate cost for all sites in alternative #1 was negligible, and only 0.02% in alternative #2. They appear to be a very cost effective practice, perhaps because few crossings were needed on the study sites. Keeping equipment out of streams also is one of the best means of protecting water quality.

Streamside Management Zones

Streamside management zone costs also were low. There were no costs for SMZs in alternative #1. This was expected, since Georgia does not require leaving any timber in SMZs. However, the streamside management zones mandated in alternative #2 were surprisingly inexpensive. Even when a residual timber requirement was placed on all perennial and intermittent streams, SMZ costs were only 0.4% of the total gross harvest revenue. These costs were largely from timber left unharvested in the primary zone. This zone covered an average of 4.7% of each study sites' forestland, or about eight acres per site.

Streamside management zones proved to be a surprisingly cost-effective practice. However, the amount of forestland in SMZs and their accompanying costs could have been underestimated for several reasons. Intermittent and perennial streams on each site were identified by studying USGS topographic maps. These maps probably do not show all the active streams on each site, and some drainages which appear to be dry on the maps may actually qualify for SMZ protection. Thus, additional residual timber and road construction costs may have been missed. An actual examination of each site would be necessary to more accurately determine each stream's classification. Under-estimation was probably greatest in steep areas with their complex drainages and least in flatter, coastal plain sites.

There were also other costs associated with SMZs which were not modeled. These include decreased production during forest harvesting and SMZ protection during site preparation with fire or herbicides. These costs would also increase if aditional miles of stream were given primary or secondary zone protection.

Since it was likely that SMZ costs were underestimated, sensitivity analysis was done on these costs. Study costs for SMZs were increased by a factor of two, and a factor of four. The effect of these increases on the relative ranking of BMPs by cost and change in total per acre costs were examined.

There were no SMZ costs for alternative #1. In alternative #2, per acre costs rose from $26.98 to $28.94 (2x) and $32.85 (4x). In terms of total gross revenue this was an increase from 5.2% to 5.6% and 6.3%. In the original analysis, SMZs were the fifth most expensive practice. The two-fold increase changed the ranking of SMZs to fourth most expensive. However, increasing SMZ costs by a factor of four made SMZs the second most expensive practice behind seeding.

Geographic Region and Topography

BMP costs between the geographic region and individual site topography groupings of study sites were studied by comparing costs in steep/mountain, moderate/piedmont, and flat/coastal plain sites. Costs in the groups were very similar. One important criteria for distinguishing between geographic regions is their average slope. Though the percent slope at specific sites can vary inside these regions, it is assumed to stay within a relatively narrow range.

Despite this variation, BMP costs in topographic groupings of the study sites were similar to their related geographic groupings. BMP costs are a function of the amount or number of BMP practices required. These BMP amounts are an approximation or index of each sites' vulnerability to nonpoint source pollution. Thus, these strong similarities in cost lend weight to the application of BMPs by geographic region, as opposed to individual site percent slope. It is much easier for landowners or forest operators to accurately identify the geographic region of a site, rather than its percent slope. Since ease of application is an essential part of effective BMP practice manuals, this is a significant finding.

The control forest practices functioned as a baseline against which costs of recommended Georgia BMPs and enhanced BMPs were judged. The analysis attributed no BMP costs to the control forest practices--only to improved practices that would cause additional costs. Although roads and other logging costs were incurred by all systems, we only wanted to measure cost increases required by use of BMPs, not total logging costs. The BMP costs were then measured as a percentage of total stumpage value and on a per acre and per MBF basis. The aggregate costs of alternative #1 represented the collective cost of implementing Georgia's suggested forest land management practices, as compared to the control. The combined cost of all BMPs was $39,062 or 4.2% of gross harvest sale revenues. In terms of all softwood and hardwood timber volume, BMPs cost $3.50 per MBF, or $21.73 per acre.

The collective costs of the more restrictive BMPs in alternative #2 followed a slightly different pattern. Total BMP costs increased to $48,510, or about 5.2% of gross stumpage revenue. Added protection for streamside management zones and use of seed, fertilizer and mulch were the principal factors increasing costs with enhanced BMPs. Expressed in terms of softwood and hardwood timber volume, costs for enhanced protection were $4.34 per MBF; this was a per acre cost of $26.98.

The most expensive practices for both recommended and enhanced BMP alternatives were consistently: 1) seed, fertilizer, and mulch application; 2) broad-based dips; and 3) water bars. The least expensive practices were typically stream crossings and streamside management zones.

Costs by Geographic Region

As one would expect, mountain study sites had the largest BMP costs as expressed in total dollars, percentage of gross harvest revenue, by timber volume, or by acre. This was largely a function of their steep slope, which increased the amount and number of BMPs required. Broad-based dips, water bars, and road retirement costs dominated BMP expense in alternative #1 and #2. The mountain sites were the only area in which BMP standards required changes in the layout of temporary forest roads.

Recommended Georgia BMP costs in the Piedmont were less than those for the mountains in terms of total cost, cost by timber volume, and cost per acre. They amounted to only half as much of the gross harvest revenue. Broad-based dips, water bars, and road retirement practices were the most expensive. Enhanced BMP (alternative #2) costs were also lower in the piedmont than in the mountains, in all respects.

Water quality protection costs in low relief coastal plain sites were minimal for both alternatives. In alternatives #1 and #2, only 1.4% and 2.5% of the respective gross harvest revenue would be required to implement BMPs. The trio of broad-based dips, seed and fertilizer, and water bars were the most expensive practices in both alternatives. There were no SMZ costs in alternative #1; in alternative #2 they were only 0.2% of gross revenues, and were the least expensive of all the BMPs.

Costs by Topography

The study sites also were classified as steep, moderate, or flat following Soil Conservation Service guidelines (USDA Soil Conservation Service 1973). Steep sites had an average slope of over 9%, moderate sites had slopes of 4% to 8%, and flat sites had slopes of 0% to 3%.

Land management costs in the steep study sites were higher than other topographic regions in all respects. As study site average slope decreased, so did BMP costs. Broad-based dip, water bar, and road retirement practices were the most expensive BMPs in all terrains, and for both alternatives. Streamside management zones were among the least expensive BMPs. Stream crossing costs were negligible in all regions.

On steep sites, broad-based dips and seed, fertilizer, and mulch application were the most expensive practices of the recommended Georgia BMPs. Water bars made up most of the remaining cost, together with additional road construction expenditures. There were no costs for stream crossings or SMZs. For enhanced BMPs, seeding costs replaced dips or water bars as the most expensive single practice. Despite the large primary SMZ required in the mountains, costs from leaving residual timber amounted to only 0.48% of gross stumpage revenues.

On sites with moderate topography, the total cost of applying existing state BMPs in alternative #1 was only 3.1% of these sites' gross harvest revenue. As usual, broad-based dip, water bar, and road retirement practices were the most expensive. BMP costs rose in alternative #2; the most significant increases were for road retirement and SMZs. However SMZ costs still equalled only 0.5% of gross harvest revenue.

Only one of the cases examined in Georgia was flat. It also had no streams or lakes requiring BMP protection,

which further lowered costs. Recommended Georgia BMP costs were very low, totalling 0.5% of gross harvest revenue. Total costs for enhanced BMPs increased, but still equalled only 1.0% of the flat sites' gross revenue. Seed, Fertilizer, and mulch costs increased substantially as sites became steeper, because their use was required over much larger areas.

CONCLUSIONS

Several trends in BMP costs appeared in the study. The control harvesting practices had no costs associated with best manaement practices. As BMPs were applied to forest harvest sites, costs increased. Mountainous regions or sites with steep terrains had the highest BMP costs. As the average slope decreased in the piedmont and coastal plain, so did BMP costs.

The lowest costs were typically in flat coastal plain forest lands. The most expensive BMPs were usually 1) seed, fertilizer, and mulch application; 2) broad-based dips; and 3) water bars. Streamside management zones and stream crossing BMPs were among the most inexpensive and cost-effective practices. The total cost for current state BMPs were only 4.2% of the gross harvest revenue, or $21.73 per acre for all three states' sites. Costs for much stricter protection measures increased to 5.2%, which was about $26.98 per acre.

Mandatory BMPs may inhibit forest harvesting of economically marginal stands, or sites which are especially vulnerable to erosion and require extensive application of BMPs. On marginal tracts, standing timber value may not be sufficient to offset the additional costs of land management practices. However, southern timber harvesting has traditionally been unresponsive to changes in market price or demand. Private timber is cut as landowners need the money or when timber is mature. Since the most productive timber stands are located in coastal plain areas where BMP costs are lowest, total state timber harvest volumes may not be affected much by BMP implementation. Also, the total harvest volumes removed per acre on the sites modeled were small. BMP costs per thousand would be less for harvested stands with better stocking levels.

More research is needed to forecast the many possible economic effects of mandatory best management practices. It is very difficult to forecast the effect of the pratices on timber supply and landowner behavior. It is also uncertain who will bear the costs of land and water protection. These end effects of mandatory land management practices are among the most important, and most difficult to predict.

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