

LOGGERS' PERCEPTIONS OF THE  
COSTS OF BEST MANAGEMENT  
PRACTICES ON TIMBER  
HARVESTING OPERATIONS  
IN VIRGINIA

by

E. Glen Worrell, Jr.

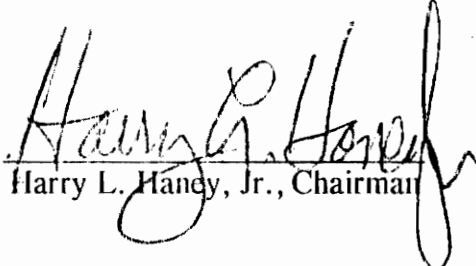
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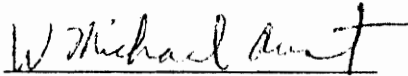
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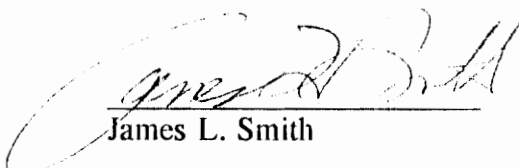
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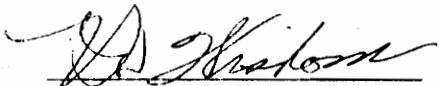
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(ABSTRACT)

Water quality practices can have a financial impact on the cost of harvesting timber in Virginia. Two hundred seventy-two timber harvesters were surveyed to determine the estimated cost for implementing best management practices (BMPs) on harvested sites. BMPs analyzed in this study are pre-harvest planning, road construction, broad base dips, water turn-outs, water bars, streamside management zones, stream crossings, and site stabilization.

Loggers provided an estimate of the cost or expense for constructing each BMP. They gave an indication of how costly these practices were to implement. The responses for each BMP were then stratified by region to determine if there were regional differences in the unit costs. With the exception of haul road construction costs, the data showed no regional differences in the unit BMP costs across Virginia.

Forty-six harvested sites in Virginia were visited to determine the number of BMPs constructed for the harvesting operations. The total cost of following BMP guidelines was calculated using the state median cost, regional road construction costs, and number of practices installed on the site for each tract. The BMP cost per acre was reported by region.

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# Chapter 1. Introduction

Environmental awareness is increasing dramatically in the world today. This is evident in the numerous articles that appear daily in newspapers and in television stories about the condition of our environment. The current environmental movement focuses on two fronts: air quality and water quality, both of which humans need for their very existence.

In the late 1800's, the early emphasis of water quality legislation in the U.S. was placed on maintaining the navigability of the nation's waters. The initial focus was on industrial and municipal discharges of gas and water pollutants into the environment. This pollution is referred to as point source or end-of-pipe pollution. Point source pollution can be traced to the original source or responsible party.

After point source problems were addressed, the environmental movement of the 1970's broadened the focus of water pollution to include non-point source pollution. Unlike point source pollution, non-point source pollution cannot be traced to a particular source. Pollution resulting from development, landscaping, farming, and silvicultural activities are considered non-point sources of pollution.

The American public's concern regarding forestry operations include, but are not limited to, the visual impact of timber harvesting, the health and safety risks of pesticide application, smoke and particulate problems of prescribed burning, perceived habitat destruction of threatened and endangered species, and concern for water quality

(Cubbage and Siegel 1988, Siegel 1989, and Martus 1992). Forestry activities, and timber harvesting practices in particular, are under increasing scrutiny as public support for environmental protection grows. Opposition to clear cutting, stream siltation from harvesting operations, and preservation of native trout and salmon fisheries are issues that have increased regulatory action (Siegel 1989, and Goetzl and Siegel 1980).

The many regulatory developments reflect the increased concern of the American public. These include the expansion of state forest practice regulations to address a broader range of environmental issues (Siegel and Haines 1990), the enactment of new federal environmental quality statutes (Siegel and Haines 1990), and the proliferation of local ordinances that regulate forestry activities (Martus 1992).

For forestry professionals, the impact of environmental regulations on the financial aspect of forestry can range from minimal to devastating. For example, environmental regulations can be as simple as flagging stream buffer zones or as complicated as requiring harvest permits which could eliminate the profitability of harvesting a particular tract of timber. Foresters need to know the potential economic effects resulting from the water quality practices, as well as how to reduce the physical impact of silvicultural practices on the environment.

Water quality practices that reduce the amount of non-point pollution are becoming increasingly important in terms of time and money to the forestry profession. The primary type of pollution resulting from a timber harvesting operation is sedimentation (Siegel 1989). The loss of top soil, the most productive element on a

timber site, reduces the productive capacity of the land. Implementing practices that reduce erosion will not only decrease sedimentation that results from timber harvesting operations, but will also preserve site quality. An indirect benefit realized by landowners is the pride in knowing that they are being good stewards of the forest.

Reducing sedimentation in streams directly benefits society by lowering the costs of operating treatment facilities. Increased water-based recreation activities such as fishing, swimming, and boating are indirect benefits.

With the increasing pressure for water quality protection, both voluntary and regulatory practices have evolved to reduce water pollution that results from timber harvesting operations. However, the implementation of these practices has the potential to increase costs for both loggers and landowners. Higher harvesting costs can reduce the net revenue received by the landowner, thus making forestry investments less attractive for investors.

In meeting the goal of improving water quality standards, certain practices and procedures are more efficient at reducing pollution than others. Loggers, foresters, and landowners need to be able to determine which practices are best at reducing pollution and sedimentation from specific timber harvesting operations. However, to determine the financial impact of implementing the practices, the cost of implementing each BMP needs to be calculated to effectively plan harvesting operations and public policy.

## **History of Water Quality Legislation**

Concern for water resources in the United States was born very early in the history of the country. Beginning in the late 1800's, federal legislation was enacted to protect navigation within the nation's waters. Legislation protecting the water quality of the nation's streams and lakes was not implemented until the 1950's and 1960's. The initial water quality legislation was aimed at reducing the amount of point source pollution being emitted into lakes, rivers, and streams (Federal Water Pollution Control Act Amendments of 1972, PL 92-500). As point sources of pollution were addressed, awareness started to increase over the impact on water quality from nonpoint-source pollution.

Section 319 of the Water Quality Act of 1987 (PL 100-4) required the states to implement voluntary or regulatory controls of nonpoint-source pollution. Since most forestry activities are considered non-point source in nature, this section affected forestry practices. The recommendations for forestry were developed into a series of applications known as best management practices (BMPs) (Hawks et al. 1993). Several western and northeastern states decided to develop regulatory BMPs for forestry related practices, although Section 319 did not require the adoption of mandatory regulatory water quality programs if acceptable performance levels were achieved. Virginia chose to implement a voluntary BMP program.

## **Regulatory Versus Voluntary Standards**

In general, state legislatures establish regulatory BMP standards for protecting water quality, whereas administrative agencies establish voluntary BMPs. States with Forest Practice Acts follow a form of regulation process (Martus, 1992). For example, a regulatory standard can be as simple as requiring a permit before crossing a stream or as complicated as requiring approval of a pre-harvest plan. Regulations must be met before timber can be harvested. In states with voluntary BMPs, the results tend to focus more on outcomes -- expected results -- than on process. Voluntary practices are designed to reduce sedimentation, but are not legally required for a harvesting operation.

As an example of a state with an outcome-based approach, Virginia's water quality program with voluntary BMPs differs dramatically from those of its neighbors. Virginia's forestry community concluded that voluntary BMPs could be most effective in improving water quality. Virginia implemented this approach with logger education, on-site inspections, and discussion at the field level. By way of contrast, Maryland has an erosion and sediment control program that imposes strict state controls over non-point source pollution management (Hawks et al. 1993). West Virginia has a newly enacted state-wide regulatory program to maintain water quality - the Logging Sediment Control Act (1992). Like Virginia, North Carolina uses a voluntary BMP program that functions as quasi-regulatory practices (1989).

## **Virginia's Approach**

Prior to 1987, Virginia's water quality program was primarily voluntary, with virtually no penalty for violation of recommended BMPs. Virginia's only law aimed at improving the water quality of streams was the Debris in Stream law (Code 1950, 62.1-194.2). If forestry activities were responsible for violating this law, there were substantial penalties and fines up to \$1,000 and/or up to 12 months in jail. The violator was responsible for correcting the problem. This law was enforced only if there was a visible problem associated with a stream, usually trash or tops and limbs. Other than this law, a logger was subject only to moral persuasion or professional pride in complying with the BMP guidelines. The anecdotal evidence suggested that the level of compliance was low to moderate.

From 1989-1991 the Virginia Department of Forestry (DOF) elevated water quality protection to the number one forestry priority in Virginia (Hawks et al. 1993). The Virginia forestry community organized a production level educational program to ensure that loggers were trained to implement the voluntary water quality programs. To help landowners, loggers, and foresters, Virginia improved its existing BMP manual. The current Virginia BMP manual for forestry activities addresses issues about harvesting, site preparation and management, revegetation of bare soil, fire protection, and wetlands (Virginia Department of Forestry 1989).

With the 1993 Water Quality Legislation, an anti-sedimentation law was enacted for Virginia (Code 1950, 10.1-1181.1 - 10.1-1181.7). Virginia can now enforce water quality regulations where "potentially severe" sedimentation or erosion



exists. If violations occur and corrective action is not taken, a maximum fine of \$5,000 per day for the violation can be imposed on the logger or landowner.

Importantly, the direct costs associated with properly executed timber harvesting may not change, but indirect costs, including potential fines, can increase in problem situations.

Both the regulatory programs and voluntary approaches are continuously undergoing revisions. The changing rules and procedures are likely to be costly for a forest landowner in both time and money. The application of BMPs, with either a voluntary or a regulatory program, has the potential to increase costs associated with forestry investments, especially harvesting activities. In order to evaluate the financial feasibility of a forestry investment, an investor considers both the costs and the benefits of the various practices before determining which activity to undertake. The concept of cost effective regulation pertaining to water quality protection programs has not been widely implemented in forest regulatory policy. This is because quantification of the costs has not been determined with any degree of precision across the scope of regulatory situations. Policy makers need to know the financial implications that both voluntary and regulatory water quality practices have on timber investments.

## **Study Objectives**

The purposes of this study in Virginia are 1) to discover the actual implementation costs of various forestry best management practices, and 2) to analyze how the costs of water quality practices can affect the cost of harvesting timber. The specific objectives of this study will be to

- 1) determine the unit cost for each BMP used in Virginia; and
- 2) examine the cost of implementing BMPs on typical harvest sites in Virginia.

This study will provide an insight into the loggers' perceptions of the costs of implementing water quality practices on harvested sites in Virginia. This will benefit resource managers and landowners who wish to conduct timber harvesting operations. This information will also be useful to governmental agencies that impose water quality guidelines by identifying the economic consequences of timber harvest regulation.

## **Chapter 2. Literature Review**

Today water quality issues are one of the major environmental concerns on the political agenda. The underlying goal in water quality protection is to ensure an abundance of clean, consumable water in the future. This literature review provides a basis for the subsequent analysis of various water quality control mechanisms.

### **History of Water Quality Legislation**

The federal government has been concerned with water resources since the early 1800's, (Holmes 1972). Throughout the 19th century the Federal planning effort focused on the navigational improvement program under the direction of the U.S. Army Corps of Engineers. The Rivers and Harbors Act of 1899 required a permit for disposal of refuse into navigable waters or their tributaries. Although this act specified a permitting process to dump refuse into rivers, there were no standards mandating water quality levels (Wisdom 1992).

After the turn of the 20th century, the government turned its attention to the west where the main concern was irrigation reserves to supply water for farm settlements (Holmes 1972). The federal government set standards pertaining to public lands and navigable waters for non-federal development of water power.

During the depression, the multiple-purpose use of water resources were made the basis of many reservoir projects. It was during the 1930's that the Tennessee Valley Authority was given authority to develop the water resources for the Tennessee

River system for the combined purposes of flood control, navigation, power generation, and regional economic and social progress. The government also initiated a nationwide program of flood control improvements during the 1930's.

Sewage treatment plant construction programs also started when the federal government provided financial assistance to state and local governments. This was a significant precedent in that prior to this time, the federal government controlled most of the water related projects. The government started allowing the states and local governments to develop their own programs with federal assistance (Holmes 1972).

From the mid 1940's until the early 1960's the federal government was primarily concerned with the economic effects of water resource legislation. However, in the early 60's, the government became more active in planning for environmental purposes (Holmes 1979). Activities such as pollution control, recreation, fish and wildlife development, and municipal water supplies started receiving the governments attention.

In 1965 Congress further recognized the need to impose regulatory standards to protect water quality. The Water Pollution Control Act of 1965 (WPCA) established minimum water quality standards (WQS) on all interstate waters. The water quality standards consisted of two elements: 1) water quality criteria, and 2) a plan for the implementation and enforcement of the criteria (Holmes 1979). The WPCA focused on point source pollution. Point source pollution is discharge that is traced to a definite source, often called end-of-pipe pollution (Goetzl and Siegel 1980).

The Federal Water Pollution Control Act Amendments (FWPCA) (PL 92-500), passed by Congress in 1972, broadened the scope of the 1965 WPCA. It extended pollution control into the broader area of non-point source pollution (NPS). Goetzl and Siegel (1980) describe non-point source pollution as "...waterpollution whose source is not traceable to a particular and constant entry point, and is usually caused by land management activities." This legislation expanded the scope from targeting individual industries and municipalities (point sources) to include a wide variety of economic activities throughout the nation. An example of NPS pollution is sedimentation resulting from development, agriculture, or silvicultural activities. However, not all forestry activities are NPS in nature. Forestry activities that are point source include (1) rock crushing, (2) gravel washing, and (3) log sorting facilities. According to the 1972 Act, all other silvicultural activities are non-point in nature.

The 1972 Act includes two sections that are important to forestry -- Section 208 and Section 404. Section 208 requires states to address water quality issues and develop NPS plans (Harrington et al. 1985). Section 404 addresses the permit program for depositing dredge and fill materials into the nation's waters.

The Environmental Protection Agency's (EPA) initial effort to reduce NPS was the Model Forest Practices Act (MFPA). The MFPA was based upon California's Forest Practice Act, and it called for close monitoring of private forest practices. However, this proposal received widespread criticism, so EPA withdrew it. EPA decided to adopt the Best Management Practices (BMP) approach.

Despite the effort to define and control non-point sources of pollution, most of

the federal government's control efforts of the 1970's and early 1980's were focused on point source pollution. As problems associated with point source pollution were reduced, more attention was placed on non-point source pollution (Lickwar 1989).

This trend is evident with the 1987 passage of the Water Quality Act (P.L. 100-4). Section 319 of this act requires that each state prepare an assessment of NPS pollution problems and develop a management plan for controlling them (Lickwar et al. 1990). The NPS assessment identifies problem areas and causes, and develops management plans which specify mechanisms for controlling the non-point source pollution (Hohenstein 1987). Most importantly, this act gives the states liberty to decide if the mechanisms should be voluntary or regulatory in nature.

### **Definition of Best Management Practices**

Dornbusch and Herndon (1978) define BMPs as "...a practice or combination of practices found to be effective and practical for reducing the amount of pollutants from non-point sources to levels compatible with water quality goals." EPA [40 Code of Federal Regulations 130.2 (1)] defines BMPs as

"Methods, measures, or practices selected by an agency to meet its nonpoint source control needs. BMPs include but are not limited to structural and nonstructural controls and operation and maintenance procedures. BMPs can be applied before, during, and after pollution-producing activities to reduce or eliminate the introduction of pollutants into receiving waters."

BMPs are site-specific and should consider the watershed's natural background, as well as political, social, economic, and technical feasibility (Lickwar 1989).

## **Evolution of Virginia's BMP Program**

Prior to 1972's amendments to the Federal Water Pollution Control Act, there was not much concern, other than aesthetically, about erosion and sedimentation resulting from timber harvesting operations. In 1972 a BMP manual was published by the Virginia Division of Forestry, which was the first attempt to identify and recommend activities that could reduce the amount of sedimentation entering the state's waterways.

Beginning in 1976, a series of meetings was conducted by the Virginia Forestry Association, the Virginia Lumber Manufacturers' Association, the Extension Service at Virginia Polytechnic Institute and State University, and the Virginia Department of Forestry to inform loggers about the goals of the FWPCA. In all, over 20 meetings were held with over 700 loggers in attendance (Pennock 1977).

The first stage of Virginia's BMP program began with this effort, and it continued until 1987. The initial results were disappointing because only 42 percent of the timber harvesting operations in Virginia used BMPs (Hawks et al. 1993).

Nineteen eighty-seven was also the year the Clean Water Act amendments (CWA) were adopted by Congress. The CWA amendments included a new section, Section 319, which dealt with the best management practices aimed at reducing non-point source pollution. It required states to devise and implement practices that would reduce the amount of sedimentation entering the nation's waterways. Since Section 319 left the decision up to the states as to whether the BMP program should be voluntary or regulatory in nature, the result was predictable. Given this latitude,

Virginia determined that its BMP program would be most effective if it remained voluntary.

This begins the second phase of Virginia's BMP program. The Virginia BMP manual was revised and updated to broaden the scope to all aspects of forestry activities. This revision of the BMP manual is currently being used in the state. It addresses issues pertaining to timber harvesting, site preparation, forest management, revegetation of bare soil, forest protection, and wetlands (Virginia Department of Forestry 1989).

In addition to revising the manual, Virginia aggressively promoted the program with various meetings and workshops throughout the state. Department of Forestry personnel inspect all harvesting sites at least twice. One inspection is made while the logger is on the site, and any problems that are observed are addressed on the site. A final inspection is carried out after the harvest's completion. The Department of Forestry's commitment to maintaining water quality was further emphasized between 1989 and 1991 when the Department elevated water quality to the number one forestry priority (Hawks et al. 1993). The Virginia Department of Forestry documented the compliance rate for this phase of the program at 89 percent (Aust et al. 1996). Although the second phase increased BMP compliance rates, it did not contain procedures for dealing with loggers who create excessive sedimentation in streams.

The third phase of Virginia's BMP program evolved in 1993 when performance standards were incorporated with the passage of an Anti-Sediment Law. It is also known as the "Bad Actor Law". Virginia's program is now regulatory in nature.



Loggers are permitted to do BMPs voluntarily, but they are required to use BMPs to prevent sedimentation from entering bodies of water.

Under the third phase of the program, compliance rates are believed to be about 95 percent (Aust et al. 1996). A problem may exist, however, with the compliance rates that are reported. The compliance rates are calculated based upon the harvested sites that are known and inspected. All timber harvesting operations in Virginia are not reported to county foresters. Therefore, it is difficult to determine with precision the total percentage of compliance.

### **Virginia BMP Audit**

Semi-annual audits of harvested sites, which began in November of 1993, were conducted to better determine the implementation levels of BMPs and the compliance rates across Virginia. The purpose of the first audit was to (1) identify current levels of BMP implementation as compared to the standards in the state BMP manual, and (2) help identify effectiveness levels for BMP's that have been implemented to DOF standards (Austin 1993). A copy of the audit form is in Appendix A.

Harvested sites were selected from more than 1,800 harvests reported to the DOF in 1993. A total of 5 harvests were randomly selected from inspections made in each of the Virginia Department of Forestry's six regions, for a total of 30 sites. Each site in a region was visited by a team of two auditors. The first audit consisted of only DOF personnel. Specific and consistent information was collected at each harvest site using a standardized BMP Implementation and Effectiveness Audit Sheet.

During the first audit, only 3 sites, or 10 percent, met the guidelines recommended in the BMP manual. The 27 sites not meeting the requirements either did not have sufficient water control structures or the existing structures were not installed according to DOF guidelines. Eighty percent of the sites did not have water quality problems at the time of inspection, but 47 percent had the potential for a water quality problem because BMP guidelines were not met (Austin 1993).

A second audit was conducted in June of 1994 and expanded the goals of the audit to identify current levels of effort in attempting to use BMPs, whether or not the practices met technical specifications. Again, 30 sites, 5 from each DOF region, were selected from harvests completed between November 30, 1993, and June 1994. Auditors included DOF personnel, along with industry and consulting foresters.

On 83 percent of the harvested sites an effort was made to apply BMPs, regardless of meeting technical specifications, but only 14 percent of the sites met all technical specifications in the BMP manual (Austin 1994a). However, this was an increase from the November 1993 audit.

Most of the sites, 86 percent, did not have a water quality problem at the time of inspection. The "potential" for development of a water quality problem existed on 45 percent of the sites. Both figures were an improvement over the preceding audit.

The third audit in November 1994 indicated an effort had been made on 83 percent of the sites, but only 13 percent of the tracts fully complied with BMP guidelines (Austin 1994b). Sites having a current water quality problem increased from 14 percent to 27 percent. A potential water quality problem due to improper

BMPs was observed on 50 percent of the sites, an increase from the June 1994 audit.

The effort to implement BMPs increased to 93 percent in the fourth audit conducted in June 1995 (Austin 1995). However, technical compliance was found on only 13 percent of the sites, which was identical to the November 1994 audit. Only 5 percent of the sites in the fourth audit had a water quality problem. A potential water quality problem existed on one-third of the sites (32 percent) (Austin 1995).

In the audits, tracts in complete technical compliance followed all procedures and recommendations in the BMP manual. All practices were installed properly. Tracts that had potential water quality problems had improperly constructed BMPs. Because of the improper construction, there is a high probability that sedimentation will enter a water source.

Although water quality problems still exist, it appears that the audits revealed an increase in the effort by loggers to implement the BMPs.

### **Costs of Best Management Practices**

Several researchers have attempted to estimate the cost of implementing BMPs in various states. Lickwar et al. (1992) analyzed BMP costs in the mountain, piedmont, and coastal plain physiographic regions of Georgia, Alabama, and Florida. The BMPs in Lickwar's study were stream crossings, broad-based dips, water bars, streamside management zones, road construction and retirement of harvested sites. The unit costs were calculated using pertinent literature and consultations with construction companies, forest contractors, forest engineers and faculty from the

University of Georgia's School of Forest Resources (Cubbage and Lickwar 1991).

The study analyzed costs under three various scenarios referred to as none (control), recommended (Alternative #1), and enhanced (Alternative #2) (Cubbage and Lickwar 1991). The number or amount of each selected BMP that was used in each scenario was based on estimates made from topographic maps of each harvested site. The numbers in each level were then multiplied by their unit cost to determine a total cost per BMP. The study does not validate the estimated BMPs with the number actually implemented on the ground. After determining the total BMP costs for the site, the average cost per acre was reported for each scenario (Table 2.1).

Table 2.1. Cost of BMPs in the mountain, piedmont, and coastal plain regions of Georgia, Alabama, and Florida (Cubbage and Lickwar 1991).

Geographic region	Alternative #1 per acre cost (\$)	Alternative #2 per acre cost (\$)
Mountain	32.90	36.27
Piedmont	22.43	28.13
Coastal plain	8.62	15.77

In southwestern Minnesota, Ellefson and Weible (1980) estimated the marginal costs of implementing practices to reduce forestry pollution. They accomplished this by analyzing the effects of certain water quality practices on a timber buyer's net revenue. Four practices were studied: streamside filter strips, buffer strips, seeding of

skid trails and landings, and designing skid trails. The filter strips and buffer strips were analyzed at various distances -- 30 and 60 ft. for filter strips and 30, 60, and 100 ft. for buffer strips.

Ellefson and Weible found that leaving filter strips of 30 and 60 feet increased total harvesting costs by \$12 and \$44, respectively. Leaving buffer strips of 30, 60, and 100 feet increased the total costs by \$80, \$160, and \$266, respectively. Seeding the landings and skid trails cost an additional \$81 and designing skid trails cost an additional \$550. Requiring one or more of these practices can greatly increase harvesting costs.

Ellefson and Miles (1984, 1985) analyzed data from 18 national forest timber sales in the Midwest, and they employed an approach to estimate the incremental costs of six practices to reduce sedimentation. Skid trail and landing design, culverts, water bars, broad-based ditches, seeding and fertilizing landings and skid trails, and buffer strips near bodies of water were evaluated in the study. For a "composite" sale, the total harvesting costs with conventional practices were \$1,137,595, and the net revenue was \$124,340. The total composite cost increases that accompanied implementation of the practices were \$1,556 for skid trail and landing design, \$6,203 for culverts, \$9,031 for water bars, \$10,946 for broad-based ditches, \$19,908 for seeding landings and skid trails, and \$25,948 for buffer strips for streams (Table 2.2).

Table 2.2. Total incremental costs for implementing various practices to reduce sediment from timber harvesting practices in the Midwest (Ellefson and Miles 1984, 1985).

Sediment reducing practice	Incremental costs total (\$)
Skid trail and landing design	1,556
Culverts	6,203
Water bars	9,031
Broad-based dips	10,946
Seeding landings and skid trails	19,908
Buffer strips for bodies of water	25,948

These studies analyzed the costs of BMPs from a theoretical standpoint, assuming total compliance with BMPs. However, not all harvested sites will totally comply with the recommended BMP program. Some sites may be in only 50 percent compliance, which still indicates that the logger has attempted to implement BMPs. The logger incurs costs in attempting to follow water quality guidelines, regardless of the compliance level.

Therefore, the implementation costs need to be determined by analyzing the actual number of BMP structures that are used in typical timber harvesting operations. To the best of my knowledge, no studies have attempted to analyze the actual costs of BMPs that have been implemented on harvested sites -- either per acre or by harvested tract.

### **Cost Comparisons**

Hawks et al. (1993) compared Virginia's voluntary BMP structure with the layers of regulatory requirements imposed by Maryland. In this study, Maryland's regulations were imposed on hypothetical timber transactions for comparison with Virginia's voluntary program in order to estimate the costs and time impacts of the respective programs for landowners in each state under similar circumstances.

The financial aspects of the added cost of timber production associated with various water quality regulations were then analyzed. Hawks et al. (1993) concluded that Virginia's voluntary program costs are less than Maryland's regulatory approach when compared on a volume harvested basis.

A relatively large body of literature exists concerning forestry BMP methodology and water quality impacts (Golden et al. 1984, Lynch and Corbett 1990). However, insufficient information exists concerning who bears the costs of implementing various BMPs among the landowner, logger, or timber buyer.

### **Timber Harvesting Activities**

Simply cutting trees has no effect on the levels of sedimentation available for erosion (Golden et al. 1984). The authors of several studies concluded that the act of felling trees does not result in an increase in stream sedimentation (Likens et al. 1970, Lieberman and Hoover 1948, Douglas 1974, 1975, 1979, and Brown 1970, 1974). However, the activities that are required to remove the felled trees -- skidding, loading, and hauling -- have the potential to increase the levels of disturbed soil area which can

lead to high amounts of erosion (Lickwar 1989).

Sources of pollution resulting from forestry activities are sedimentation, pesticides, herbicides, fertilizers, changes in stream temperature, logging debris in streams, and trash left on logging sites (Siegel 1989). Sedimentation is the primary pollutant resulting from forestry operations (Golden et al. 1984, Goetzl and Siegel 1980).

Sedimentation can generally be traced to stand access, skid trails, and logging decks used in the timber harvesting operation. The most detrimental effects of the erosion occur when the sedimentation comes in contact with streams or major water ways. However, only 10 percent of the sediment load in streams and waterways is related to forest management activities (Pennock 1977).

There are several characteristics of a timber site that can determine potential damage to water quality resulting from timber harvesting. Factors such as cover type, soil type, slope and aspect can give an indication of the potential for water pollution. Another factor which is generally regarded as the most important is the amount of care and planning involved in pre-harvest planning and in the actual harvest (Anderson et al. 1976, Aubertin and Patric 1972, 1974, Yoho 1980).

Previous studies provide insights into loggers' attitudes toward BMPs. In a survey of southern timber harvesters and loggers, Martus (1992) determined that when compared to various other timber harvesting regulations, BMPs ranked the lowest among all the regulations that were considered. In Martus' study, activities considered as having costs ranking higher than BMPs were requiring harvesting permits, requiring



performance bonds, notifying public officials, and having a management plan approved by a forester.

### **Summary**

Water quality issues have received widespread attention from the American public during the last ten years. This attention translates into increased concern over activities and procedures that are needed to reduce the level of pollution entering the nation's waters. One of the most important developments is increased attention placed on timber harvesting activities.

Various practices have been designed to help reduce silviculturally generated pollution from entering streams. Several states have chosen to implement voluntary BMPs, while others have elected a regulatory approach that they feel is more practical. Regardless of the method, the practices have the potential for increasing harvesting costs.

This subject requires a careful analysis of the costs associated with the BMPs to control water pollution. In addition, information on loggers' perceptions of the costs of water quality control practices will be valuable to forest resource managers, landowners, and government agencies who are responsible for managing water quality implementation goals.

## **Chapter 3. Methods and Procedures**

Procedures to protect water quality are an increasingly important component of business for timber harvesters in Virginia. These procedures affect pre-harvest planning, actual harvesting operations, and post-harvest stabilization of disturbed areas. Such practices should be analyzed to determine which ones produce the most cost-effective results from a financial standpoint while producing desirable water quality protection.

Silvicultural activities such as harvesting, timber stand improvement, and timber stand regeneration can affect water quality in several different ways. During timber harvesting, the main objective is the removal of all or part of the merchantable timber. Activities commonly associated with timber harvesting include construction of access roads and skid trails, and preparing log decks or loading areas. The objective of stand establishment is to ensure a healthy, vigorous stand for the future, which may require site preparation, planting, and a release operation. Accomplishing these goals usually involves activities that disturb the soil, thus creating the potential for erosion and sedimentation.

This study is separated into three sections: (1) a survey of timber harvesters to collect information on the unit costs for various BMPs; (2) an analysis of the timber harvesters' perceptions of the costs of water quality practices in Virginia; and (3) an examination of the cost per acre of implementing BMPs on timber harvesting operations. The procedures described in this chapter represent an analysis of forestry

harvesting practices aimed at improving water quality in the state of Virginia. Results from this study should also serve as a basic source of information for future research on forest water quality practices in Virginia.

In this study, loggers are referred to by the masculine gender. This is simply a recognition of the fact that there are no women who harvest timber in Virginia rather than a gender bias.

### **Survey of Timber Harvesters in Virginia**

A comprehensive analysis of the costs of BMPs is an important aspect of this study. A survey was designed to determine the logger's estimated cost of each BMP and to elicit the logger's perception of the cost of implementing BMPs. The practices included in the loggers' survey were based on previous research (Cubbage and Lickwar 1991, Lickwar et al. 1992, Ellefson and Miles 1984, Ellefson and Miles 1985). It also included practices recommended in the Forestry Best Management Practices for Water Quality in Virginia, a manual developed by the Virginia Department of Forestry (1989). The best management practices analyzed were (1) pre-harvest planning, (2) haul road location and construction, (3) broad base dips, (4) water turn-outs, (5) water bars, (6) stream side management zones, (7) stream crossings, and (8) post-harvest revegetation practices -- seed, fertilizer, and mulch. Survey subjects were the loggers who had harvested timber within the state of Virginia. The survey instrument is reproduced in Appendix A.

A list of the 1,089 loggers and timber harvesters in Virginia in 1993 was

obtained from the Virginia loggers directory (Virginia Department of Forestry 1993). A random sample of 272 loggers was drawn from this list. Each timber harvester in the sample was mailed a questionnaire. More detail on this point is given below.

The physiographic region of the state in which the respondent harvests timber -- mountain, piedmont, or coastal plain -- was obtained from Question one. To assist participants in determining which region of the state they operate in most frequently, the areas were defined as Coastal Plain, east of Interstate 95; Piedmont, west of Interstate 95 and east of the Blue Ridge Mountains; and Mountain, west of the Blue Ridge Mountains (Figure 3.1). With this information, the responses can be grouped according to region of operation. Regional differences in unit costs, if they exist, can be determined by analyzing cost data according to physiographic region.

The elevation of Virginia ranges from sea level to 5,729 feet. Due to the differences in elevation and terrain, timber harvesting practices can vary considerably across the state. For instance, in the coastal plain region, direct skidding to landings is more prevalent than in the mountains, where the use of constructed skid trails is more common.

Tract size can have an effect on the cost of BMPs. Each logger surveyed was asked to give the size of the tract he typically harvests -- smallest, average, and largest (Question 2). Generally, operators on smaller tracts are expected to have higher unit costs than similar operators on large tracts.

For the eight practices listed above, the participants were asked to give estimates of both the time and cost for implementing each individual practice

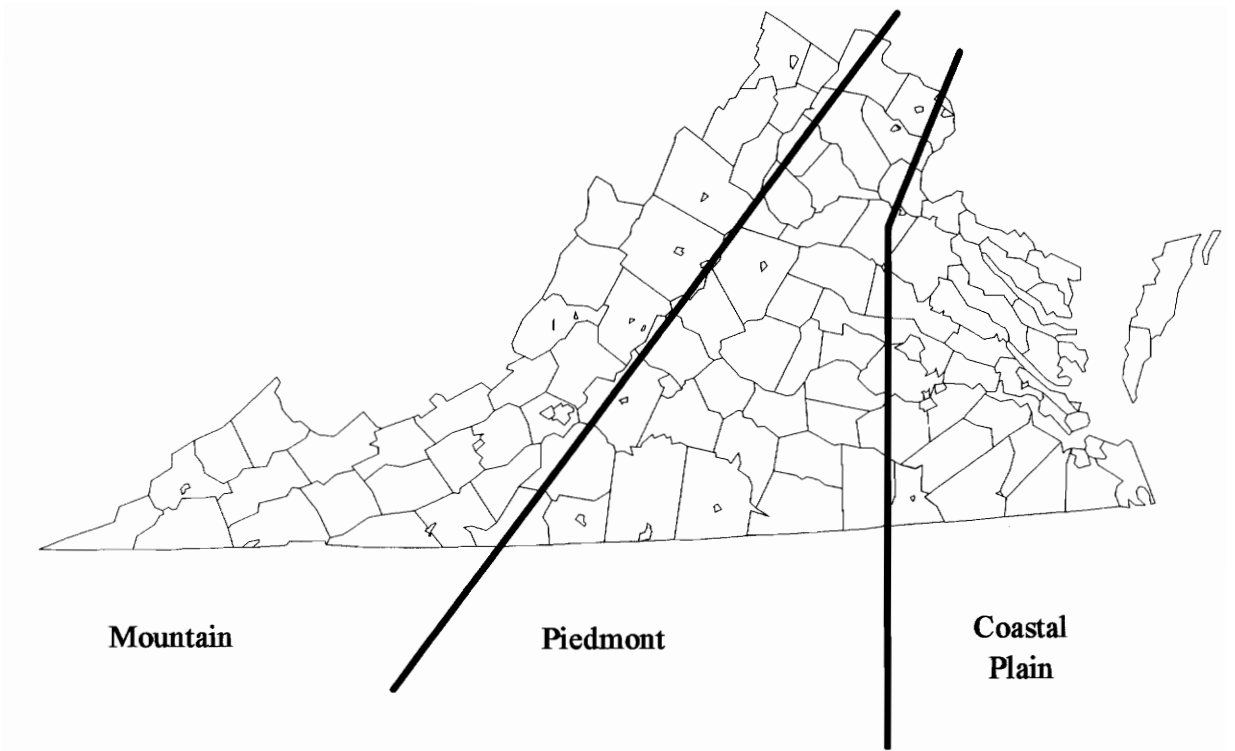


Figure 3.1. The physiographic regions of Virginia.

(Questions 3 through 7). To help the participants arrive at the unit cost, they were asked to consider labor, machine cost, and supplies, such as flagging and paint, needed for construction. If a certain practice required equipment use, the participant was asked to indicate the type of equipment used in construction -- skidder, dozer, or other. For example, constructing a water bar might require the use of a dozer, skidder, or other piece of equipment.

With this information the unit cost for each BMP was calculated in the three physiographic regions of Virginia. The regional averages were then compared to determine if there was a significant regional difference. If no significant differences were observed among the three regions, the data was collapsed to represent a statewide average.

Respondents were asked whether they had actually constructed and implemented the various BMPs (Question 8). This question was used to see who actually implemented the BMPs on the participant's job. Possibilities included the harvester, the company purchasing timber, or a BMP contractor. The purpose of the question was to discover who is taking the greater initiative for implementing BMPs, the timber harvester or the timber buyer. This data determined the percentage of timber harvesters who constructed BMPs themselves.

The Department of Forestry implemented an intensive educational effort in 1989 by holding workshops that were jointly sponsored with Virginia Tech and Virginia's forest industry. The purpose of the workshops was to make timber harvesters aware of BMPs. The workshops included discussion of the importance of

BMP implementation and technical specifications for following the BMP guidelines. Each survey participant was asked if he had attended a BMP workshop offered by the Virginia Department of Forestry, Virginia Tech, or forest industry (Question 8a). If the individual indicated he had not attended a workshop, he is asked to briefly explain why. This information shows the percentage of timber harvesters in Virginia that has had some form of BMP training and the potential need for additional training under such programs as the Sustainable Forestry Initiative for logger education.

Participants were finally asked to rank each of the BMPs for controlling non-point water pollution. Participants were provided an ordinal scale consisting of (1) easily implemented at little cost; (2) moderately difficult, moderately costly; (3) difficult or costly to implement; (4) extremely difficult, extremely costly. A "no opinion, no comment" category was also provided. This will show the timber harvester's perception of the unit cost of each BMP recommended for harvesting operations in Virginia.

The methodology for the mail survey used in this study was based on the principles of D.A. Dillman (Dillman 1978). An initial mailing was sent to each participant, containing a personalized cover letter and survey form. Ten days after the initial mailing, a postcard was mailed to each participant reminding them of the survey and asking them to complete and return it if they had not already done so. The final mailing was distributed three to four weeks after the postcard. Before the final mailing, an attempt was made to contact by telephone those who had not responded. This was done to verify the correct address, and to alert the participant to expect the

survey. Copies of the post card and cover letter are included in Appendix A.

### **Perception of the Costs for Water Quality Practices**

A regional classification system based on where the logging occurred for typical harvests -- mountain, piedmont, or coastal plain region -- was developed. Using this classification scheme, the responses were grouped according to the physiographic region in which the respondent most frequently harvested timber.

Individual responses by rank category were tallied for each practice and reported by region and by the state as a whole. The analysis determined which BMPs were considered "high cost" and which were considered "low cost" by the timber harvester. Chi-square tests were conducted to evaluate the frequency of rankings for each BMP.

The Chi-square is a goodness-of-fit statistical test based on the Chi-square distribution. It is used to determine if the actual sample distribution obtained in a study differs from an expected outcome.

$$X^2 = \frac{(\textit{observed} - \textit{expected})^2}{\textit{expected}}$$

The Chi-square distribution allows an analyst to determine the probability of obtaining an outcome as compared to an expected value (Ott 1988). Observed values with low probabilities differ significantly from the expected value, so observed values will differ from predicted values by more than would be predicted by chance (Howell 1987).



### **Determining the Actual Costs of Water Quality Practices**

After analyzing the timber harvesters' perceptions of BMP costs, the next step was to determine the unit costs of each BMP, using the responses from the survey instrument. In each region, the average cost and time of construction were calculated for each practice. For example, to determine the unit cost of one water bar in the mountain region, all of the responses for the cost of constructing a water bar in the mountain region were averaged. Each response was weighted by the average number of acres the logger typically harvests. The same procedure was followed when the average time for one water bar was calculated, again weighing the responses by size of harvest. This method was duplicated for the remaining regions and for the seven other water quality practices analyzed in the study.

The regional unit costs were then compared to determine if there are any significant regional differences. If there were no significant differences, the data was pooled and a statewide average reported. The median and range values were also reported for both cost and time data. The estimated cost was then compared to the timber harvesters' perceptions of costs to ascertain the relative financial burden of implementing BMPs as a part of the total cost of a logging operation.

### **Water Quality Costs Per Harvested Acre**

Representative harvested sites were visited to determine the numbers of each BMP implemented during the actual harvesting operation. To be eligible for selection, the harvesting operation had to be completed for the site.

Data for this aspect of the study were collected in conjunction with the Department of Forestry's (DOF) semi-annual BMP audit. This audit encompassed actual field inspections of completed harvesting operations. From the 1,400 timber harvests that had been completed in Virginia between November 1, 1994, and November 1, 1995, 45 sites were chosen at random. Twenty-five of the sites were selected from harvested jobs completed between November 1, 1994, and May 1, 1995, with the remaining 20 sites selected from harvested jobs completed between May 1, 1995, and November 1, 1995.

Each site was visited by an audit team to determine the effectiveness of the BMPs constructed for the tract. The audit team consisted of DOF employees, industry foresters, USDA Forest Service employees, EPA employees, and forestry consultants. During the team's visit, the number of each type of BMP used to close out the site was recorded. In addition to the number of practices constructed or used during harvesting, the area of the harvested site was also recorded.

The total cost for each tract from implementing Virginia's BMP program was calculated using the estimated unit cost from the logger survey times the numbers of each BMP implemented on the logging site. To determine the cost per acre, the total BMP implementation cost was divided by the number of acres harvested.

Sites were grouped by physiographic region for this aspect of the study. The topography and terrain that distinguishes the regions can be expected to have an impact on the number of each type of BMP required for a harvest. Generally, it is believed that the unit cost of a particular BMP is similar across the state. But the

differences in regional BMP costs are directly related to the number of each type of BMP required for sites within each region. This will give a more accurate estimate of regional BMP costs for Virginia's timber harvesters.

## Chapter 4. Costs of Water Quality Practices

Loggers in Virginia are responsible for implementing forestry BMPs. In this study, loggers' opinions were analyzed to determine of the cost of each individual BMP. Loggers were asked to estimate the unit cost for each BMP in the study. Harvested sites were visited to determine the number of BMP units implemented on each tract. The unit cost and site visit data were combined to achieve per acre costs.

### Survey of Loggers in Virginia

A subset of loggers was surveyed to determine the per unit costs of various BMPs recommended for harvesting operations in Virginia, as discussed in Chapter 3. Of the 272 survey questionnaires mailed, 109 persons responded, and 64 of these were loggers willing to participate in the study (Table 4.1).

Table 4.1. Survey of timber harvesters in Virginia.

Description	Number (#)	Percentage of total (%)
Surveys mailed	272	100.00
Surveys returned	64	23.53
Retired or out-of-business	21	7.72
Related activity	17	6.25
Refused to answer	7	2.57
Total accounted for	109	40.07

Of the 64 usable surveys, nine of the respondents harvest in the coastal plain, twenty-six harvest in the piedmont, and nineteen harvest in the mountain region of Virginia (Table 4.2). The regions are defined in Chapter 3, Figure 3.1, page 27.

Table 4.2. Survey responses by geographic region of Virginia.

Region of Virginia	Number of responses (#)	Percentage of total responses (%)
Coastal plain	9	14.06
Piedmont	36	56.25
Mountain	19	29.69
Total	64	100.00

Although the original sample was not stratified, it appears that the number of responses is roughly proportional to the number of loggers working in each region.

### **Loggers' Perceptions of Best Management Practice Costs**

As outlined in Chapter 3, the BMPs analyzed in the questionnaire were pre-harvest planning, road construction, broad base dips, water turn-outs, water bars, streamside management zones, stream crossings, and site stabilization. Each of these practices has a particular profile of costs and time expenditures for construction. For example, road construction, broad base dips, water turn-outs, and water bars are structures that are constructed by heavy equipment -- either a bulldozer, skidder, or back-hoe. The costs associated with these practices are for machine, fuel, and labor

plus the time required for implementation.

Pre-harvest planning activities generally consume the logger's time and occasionally requires materials such as flagging tape or boundary paint. If the tract requires a Streamside Management Zone (SMZ), establishing it also requires labor and supplies such as flagging tape and boundary paint. However, harvesting within SMZs can require additional time for the logging operation because the activity is a partial cut and care must be taken to protect the residual stand. The skidding and harvesting methods within the SMZ must be modified to accommodate partial cutting which requires more time and skill when compared to harvesting on the rest of the site.

Costs associated with stream crossings are primarily labor and equipment charges that are required to construct the crossing, plus the cost of materials needed such as culverts, bridges, and rock. For site stabilization a logger primarily incurs labor costs plus the cost of seed, fertilizer, and mulch. By using equipment such as a tractor and disc, the logger can also incur equipment costs for site stabilization.

In this aspect of the study, the loggers' perceptions of the costs of the BMPs was ascertained. The loggers' perceptions were then compared to their reported unit costs for each of the BMP practices. This should allow some insight into the marginal increment that water quality practices add to total harvest costs.

To determine their perceptions of cost, participating loggers were asked to rank the costliness of complying with each of the BMPs. Because of the limited sample size in each region, responses were collapsed into two rankings. Categories (1) and (2) were combined to create a category of "low" cost or difficulty of compliance.

Categories (3) and (4) were combined to create a "high" cost or difficulty of compliance. The no opinion rankings were omitted from this analysis. Collapsing the categories helps determine whether a significant number of respondents view each common practice as "costly" or "not costly" to comply with. These rankings are not meant to measure actual costs, but are used to reflect the relative burden that loggers face from implementing the various practices. Since such rankings were largely subjective, the original four-ranking scale provided little additional information over the two category grouping for this sample. The two-group case is also much more easily interpreted.

Although the sample size is small for both the coastal plain and the mountain regions, it seems helpful to look at the results from all three regions. The comparison shows the relative differences in loggers' perceptions of BMPs among the three regions. Total responses for the state are also reported.

### **Coastal Plain Region**

The topography in the coastal plain is relatively flat. Since the number of required practices is dependent upon slope and distance, flatter terrain requires fewer BMPs. The soil in the coastal plain region of Virginia contains a high percentage of sand. The high sand content makes the soil easier to move, thus making it easier to implement some of the water quality practices. It would appear that, under typical conditions, both factors can greatly reduce the costs and time required for constructing BMPs in the coastal plain relative to the other regions.

Based on the small number of responses it was difficult to determine the loggers' perceptions of the financial burden of complying with BMPs in the coastal plain region. Most loggers in the coastal plain region, however, perceived individual BMPs as a low cost practice rather than as a high cost practice (Table 4.3).

Table 4.3. Loggers' perceptions of BMP costs, by rank category, in the coastal plain region of Virginia.<sup>1</sup>

Best management practice	"High" cost rankings (#)	"Low" cost rankings (#)	Chi-square ( $X^2_{df=1}$ )	p-value
Water bars	3	5	0.500	.473
Water turn outs	3	5	0.500	.473
Retirement of roads and landings	2	4	0.667	.392
Stream crossings	2	4	0.667	.392
Road location and construction	2	5	1.286	.225
Broad base dips	2	6	2.000	.165
Streamside management zones	2	6	2.000	.165
Pre-harvest planning	1	7	4.500	.0382

<sup>1</sup>  $X^2_{df=1} = 3.838379$ ;  $\alpha = .05$

With the exception of pre-harvest planning, there was little difference in the loggers' perceptions of BMPs as low cost practices. Although the results did not show this conclusively, they suggest that individual BMPs are not imposing a substantial



financial burden on loggers in the coastal plain region. Since the number of required BMPs in the coastal plain is fewer relative to the other regions, a logger may not fully realize the financial impact BMPs can have on harvesting operations.

### **Piedmont Region**

Soils in the piedmont region contain a higher percentage of clay and rocky materials than similar tracts in the coastal plain region. These differences in soil composition could increase the time required for constructing or implementing unit BMPs, thus increasing the per unit costs. The topography of the piedmont region is also more hilly than the coastal plain region. Therefore, the number of BMPs required for typical harvest sites in the piedmont region will increase relative to typical harvest sites in the coastal plain. The results from piedmont loggers, however, show that they considered all individual BMPs to be a low cost activity (Table 4.4).

Table 4.4. Loggers' perceptions of BMP costs, by rank category, in the piedmont region of Virginia.<sup>2</sup>

Best management practice	"High" cost rankings (#)	"Low" cost rankings (#)	Chi-square ( $X^2_{df=1}$ )	p-value
Stream crossings	12	20	2.000	.165
Road location and construction	10	22	4.500	.0382
Retirement of roads and landings	8	22	6.533	.00783
Streamside management zones	5	27	15.125	.000378
Broad base dips	4	26	16.133	.000188
Water bars	4	26	16.133	.000188
Water turn outs	1	30	27.129	.000037
Pre-harvest planning	0	31	31.000	.0000085

$$^2 X^2_{df=1} = 3.838379; \alpha = .05$$

Although stream crossings received the most "high" cost rankings, followed by road location and construction, and retirement of roads and landings, they are overwhelmingly considered to be "low" cost (Table 4.4). The three practices most frequently ranked as "low" cost in the piedmont region were broad base dips, water bars, and water turn-outs. This suggests that loggers in the piedmont do not perceive the financial burden from individual BMPs to be especially burdensome. That is, they accept the rationale that BMPs are necessary to harvest timber and are not particularly expensive to implement.

## Mountain Region

Steeper slopes and heavy, rocky soil composition are typical in the mountain region. These slopes and rocky terrain can greatly increase the time required for implementing an individual BMP. In spite of this, loggers in the mountain region viewed most BMPs, with the exception of stream crossings, as "low" cost practices (Table 4.5). Although the responses were not significant, slightly more loggers indicated stream crossings as a "high" cost practice than as a "low" cost practice.

Table 4.5. Loggers' perceptions of BMP costs, by rank category, in the mountain region of Virginia.<sup>3</sup>

Best management practice	"High" cost rankings (#)	"Low" cost rankings (#)	Chi-square ( $X^2_{df=1}$ )	p-value
Stream crossings	10	9	0.053	.863
Streamside management zones	6	13	2.579	.120
Road location and construction	5	14	4.263	.0473
Retirement of roads and landings	5	14	4.263	.0473
Broad base dips	2	16	10.889	.001
Water bars	1	18	15.211	.000321
Water turn outs	1	18	15.211	.000321
Pre-harvest planning	0	19	19.000	.000095

<sup>3</sup>  $X^2_{df=1} = 3.838379$ ;  $\alpha = .05$

BMP practices in the mountains were ranked in an order similar to the piedmont loggers' rankings. This suggests that perceptions of financial burden were similar among loggers in the piedmont and mountain regions.

### State Totals

To determine a state-wide logger perception of BMPs, the results from collapsing the regional totals are reported in Table 4.6. Most loggers, according to the state-wide results, consider individual BMPs to be a "low" cost harvesting activity.

Table 4.6. Loggers' perceptions of BMP costs, by rank category, for Virginia.<sup>4</sup>

Best management practice	"High" cost rankings (#)	"Low" cost rankings (#)	Chi-square ( $X^2_{df=1}$ )	p-value
Stream crossings	24	33	1.421	.213
Road location and construction	17	41	9.931	.0023
Retirement of roads and landings	15	40	11.364	.00083
Streamside management zones	13	46	18.458	.000124
Broad base dips	8	48	28.571	.0000192
Water bars	8	49	29.491	.000011
Water turn outs	5	53	39.724	.0000001
Pre-harvest planning	1	57	54.069	.00000001

<sup>4</sup>  $X^2_{df=1} = 3.838379$ ;  $\alpha = .05$

The most frequently ranked "high" cost activity according to loggers state-wide was stream crossings, however, a majority of the respondents considered stream crossings "low" cost and the results are not statistically significant. The balance of the rankings with substantial "high" cost inputs are road location and construction, retirement of roads and landings, and streamside management zones. Generally, loggers overwhelmingly listed broad base dips, water bars, water turn-outs, and pre-harvest planning to be "low" cost activities. (Table 4.6).

Ellefson and Miles (1985) reported results for some practices that are similar to the practices analyzed in this study. In an analysis of incremental costs, Ellefson and Miles (1985) showed that the least expensive practices were the costs to build skid trails and plan landing design (pre-harvest planning). These were followed by culverts, water bars, broad base dips, seeding, and buffer strips. Loggers in the Virginia survey reported pre-harvest planning to be the lowest cost activity. Although many Virginia loggers indicated stream crossings as a high cost practice, it was not statistically significant, and most loggers indicated that water bars and broad base dips were low cost practices.

On harvested sites in Virginia, broad base dips and water bars are more frequent than stream crossings or streamside management zones. Because of this, loggers might be more efficient as well as more confident at constructing the water bars or broad base dips than constructing the stream crossings or designating a SMZ.

The results show that this sample of Virginia loggers views the individual BMPs as both relatively low cost and easy to implement either from a production or

time cost standpoint. Loggers were asked only to rank the individual practices, however, not the collective BMP program. These responses represent each individual practice, not the perceptions of combinations of practices needed during harvesting. It seems reasonable to conclude, based on the response to individual practices, that loggers would also view BMPs collectively as "low" cost.

### **Regional Unit Costs of BMPs**

In this section of the study the individual per unit costs for the eight BMPs will be analyzed. The per unit cost is defined as the cost for constructing or implementing one individual practice. For example, the per unit cost for constructing one water bar, one broad base dip, or one water turn-out will be examined. Also, stream crossing costs will be reported for each crossing method analyzed -- culvert, bridge, and ford. Since the number of individual practices varies according to individual harvest sites, it is appropriate to report per unit costs.

The cost for haul road construction will be reported on a per mile basis. Similarly, the costs for pre-harvest planning were evaluated on a per acre basis. The costs for loading deck, skid trail, and site seeding and stabilization will be reported for the number of decks or landings used during the harvest. These unit costs will be used to determine the total cost of implementing BMPs on harvested sites in Virginia.

Loggers' responses were grouped according to the geographic region of the state for purposes of calculating the per unit cost of each BMP. The data provided by the loggers were used to calculate the regional averages of both cost and time

estimates for constructing and implementing each BMP. The regional averages were then analyzed using "t" tests to determine if there were regional differences for a particular BMP.

When considering the costs of the various BMPs, loggers were asked to consider all costs relevant to the particular BMP. These costs include labor, machine rates, flagging, paint, and other supplies that are needed to construct or designate the water quality practice.

After analysis of the regional averages for time and cost, the results failed to show any statistically significant regional differences for BMPs, except for road construction costs. Therefore, all regional unit responses, with the exception of road construction results, were collapsed to give an average for the state of Virginia. The responses regarding road construction are reported by regions.

### **Pre-harvest Planning**

Virginia's BMP manual considers pre-harvest planning to be the collection of information about the area to be harvested that is necessary for making an effective plan. Information on site, topography, soil composition, and stream location is gathered prior to harvest in order to determine which BMPs are necessary, and how they should be implemented during the harvesting operation. This information permits the logger to effectively plan the access road, location of decks and major skid trails, and buffer strips -- streamside management zones (SMZs). Loggers were assisted in responding to the question on pre-harvest planning by being asked to consider not only

just a written plan, but also the process of becoming familiar with the tract prior to harvest.

Ninety-seven percent of the loggers sampled in Virginia reported that they had developed a pre-harvest plan. The plan was not always written, but most timber harvesters indicated that they had prepared a pre-harvest plan before beginning actual harvesting operations. Loggers reported spending an average of 7.4 hours at an average total cost of \$202.30 (Table 4.7). This cost represented the total cost for the pre-harvest planning process. These values represent the total cost for pre-harvest planning, including the costs of individual components such as flagging the haul road, skid trail and deck location, and SMZ delineation. Loggers were not asked to report these individual components.

Table 4.7. Loggers’ reported values for pre-harvest planning in Virginia.

Average		Median	
Total cost (\$)	Time (hours)	Total cost (\$)	Time (hours)
202.30	7.4	200	6

The average tract size harvested by loggers in this survey was 63 acres. Using this acreage value, loggers indicated that it costs \$3.17 per harvested acre for pre-harvest planning throughout the state of Virginia. Loggers perceive the \$3.17 per harvested acre as low cost expenditure.

In an analysis of 18 Midwestern harvesting operations, Ellefson and Miles



(1985) reported a total cost of \$1,556 for skid trail and landing design. Their average cost for skid trail and landing design was \$86.45 per harvested tract. Adjusting these costs for inflation to 1994 dollars yields a total cost of \$1,331, with a cost of \$73.96 per tract. Ellefson and Miles (1985) study results are considerably less than the Virginia loggers' reported total cost for pre-harvest planning of \$200.00 per harvested tract. However, the Ellefson and Miles (1985) study considered only the cost for skid trail and landing design.

In the present study, loggers were asked to consider all aspects of the harvesting operation, including harvest road layout, SMZ delineation, as well as designation of major skid trails and landings. Since Virginia loggers presumably considered all aspects of the harvesting operation, their reported pre-harvest planning total costs are expected to be higher than those reported by Ellefson and Miles (1985). To the best of my knowledge, no other studies have reported pre-harvest planning costs.

### **Road Construction**

The BMP guidelines (Virginia Department of Forestry 1989) for haul roads recommend road grades between 2 and 10 percent. In addition, roads should be located on a side slope, should use gravel or wooden mats at intersections with main highways, and have adequate water control on the road. Crossings for intermittent or perennial streams should use bridges, culverts, or rock fords that are placed at right angles to the stream. The degree to which each guideline affects harvesting costs can

vary among regions.

Typically, both the soil and the gentle topography in the coastal plain region make it easier to construct a logging road. By contrast, the steep slopes and rocky soils normally found in the mountain region of Virginia would lead one to believe that the costs of road construction would be higher. Costs in the piedmont region should fall between those of the coastal plain and mountain regions. Thus, the usual working hypothesis is that the least expensive costs for road construction should occur in the coastal plain region and the higher costs should occur in the mountain region.

Loggers were asked to report their costs of constructing a one mile haul road that complies with BMP guidelines. Also, loggers were asked to estimate the cost of constructing a road that does not follow BMP guidelines, but would be sufficient to harvest the timber. Reporting the costs for the two different roads should indirectly give the cost of following BMPs for haul road construction. Note that a contingency question such as this will not illicit as reliable an answer as if the logger had to actually follow through with the road construction. But the answers will provide some insights as to the cost differences in the two types of roads.

To assist loggers with the question, they were given the following guidelines: "for haul road in compliance with BMPs, maintain grades between 2 and 10 percent, locate on side slope, and use gravel or mats at intersections with main highway, etc. For haul roads not in compliance, ignore the guidelines of the BMP manual." Respondents were asked to report the cost and time per mile for constructing a haul roads under both situations.

Loggers in the three regions of Virginia reported a significant difference in the cost of road construction. Therefore, time and cost responses associated with road construction are reported by region.

#### Without Following BMP Guidelines

Loggers in the piedmont region reported the highest average log road cost at \$1,389 per mile which required 14.8 hours to construct (Table 4.8). Next, loggers in the mountain region reported an average cost of \$990 per mile which required an average of 10.4 hours to construct. Coastal plain loggers reported an average cost of \$667 per mile which required 4.1 hours to construct (Table 4.8).

Table 4.8. Loggers' reported costs and time for constructing one mile of a haul road that does not comply with the BMP manual in each geographic region of Virginia.

Geographic region	Average values		Median values	
	Cost/mile (\$)	Time/mile (hours)	Cost/mile (\$)	Time/mile (hours)
Coastal plain	667	4.1	600	4
Piedmont	1389	14.8	1,025	12
Mountain	990	10.4	902	8.5

According to loggers, the most expensive region in which to construct a mile of haul road that does not follow BMP guidelines was in the piedmont region, rather than

in the mountain region as expected. Loggers in the piedmont region reported an average time of 14.8 hours to construct one mile of haul road that does not comply with BMPs, which is 4.4 hours longer than what loggers reported in the mountain region.

This seems a bit unusual. As mentioned earlier, the slope and soil composition should increase the time required to construct a mile of road in the mountain region as compared to the other regions. Possibly, the respondents did not fully understand the question or consider all costs associated with road construction. These responses should have reflected the cheapest cost of constructing an access road without following BMP guidelines, but perhaps they reflect wishful thinking for a time before BMPs. Most likely, however, the sample size may simply have been inadequate for an accurate estimate of this variable.

#### Following BMP Guidelines

The cost of an access road that follows BMP guidelines is presented in this section of the study. Prior to the BMP guidelines, loggers could construct an access road without having to worry about grade, stream crossings, and an entrance onto main highways. As BMPs evolved, loggers were strongly encouraged to follow the guidelines. The BMP guidelines (defined earlier) have resulted in an increase in the amount of time required for constructing haul roads. Also, they have increased the need for materials such as gravel and mats, which the logger is responsible for supplying.

Loggers reported that the highest cost for constructing a log road that follows BMP guidelines occurred in the mountain region. These cost estimates are followed by the piedmont and coastal plain regions (Table 4.9).

Table 4.9. Loggers' reported costs and time for constructing one mile of a haul road that follows BMP guidelines, by region.

Geographic region	Average		Median	
	Cost/mile (\$)	Time/mile (hours)	Cost/mile (\$)	Time/mile (hours)
Coastal plain	1,450	9.5	1,249	9.5
Piedmont	2,417	23.5	1,690	21
Mountain	2,756	29	1,703	26

In the mountain region, loggers reported an average cost of \$2,756 per mile that required 29 hours to construct, and median values of \$1,703 and 26 hours per mile. Piedmont loggers reported an average cost of \$2,417 per mile which required an average of 23.5 hours to build. Loggers in the piedmont region reported median values of \$1,690 and 21 hours per mile. Coastal plain loggers reported an average cost of \$1,450 per mile which required 9.5 hours to build. The median values reported by loggers in the coastal plain region were \$1,249 and 9.5 hours per mile.

The costs for haul road construction by region increases as the activity moves from the coastal plain to the mountains when loggers follow the BMP guidelines. As expected the largest road construction costs are reported in the mountain region.

Previous studies by Cabbage and Lickwar (1991) have shown this trend. They reported costs for road construction to be highest in the mountain region of Georgia, followed by the piedmont and coastal plain regions.

However, when comparing the median costs of following BMP guidelines with the loggers' perceptions of the cost, the results were somewhat puzzling. In each region, the loggers viewed the costs associated with road location and construction as a low cost activity. Yet loggers indicated that following BMP guidelines increased their cost by \$649 per mile in the coastal plain region, by \$665 per mile in the piedmont region, and by \$801 per mile in the mountain region. The responses indicate that these increases are not borne by the loggers, but they are passed on to the buyers in terms of higher logging costs, or alternatively passed back to the landowner in terms of lower stumpage rates.

Loggers may not view these increases only in terms of actual cost, but in terms of the cost of doing business. Obviously, following the BMP guidelines can have a substantial impact on overall costs, and they have a proportionally greater impact in the mountain region.

### **State Unit Costs for Common BMPs in Virginia**

The three structures that are the most frequently implemented on timber harvesting operations in Virginia are water bars, broad base dips, and water turnouts. Each logger in the sample was asked to give estimates of the time and cost for each of these BMPs.

A water bar is basically a trench or ditch constructed across access roads or skid trails to divert water from the road's or trail's surface. Water bars are typically installed on roads and skid trails that restrict vehicular traffic. Conversely, heavy vehicular traffic reduces the effectiveness of water bars.

Broad base dips and rolling dips consist of a dip and reverse slope that provides cross drainage on a road surface. They are constructed and installed on road and skid trails that will have vehicular traffic after harvest. These structures can be effectively maintained to keep water off the road or skid trail without impeding traffic flow.

A water turnout or diversion ditch is a trench that is constructed adjacent to an access road or skid trail. The purpose of the turn-out is to move water away from the road ditch and disperse the water.

To determine the level of implementation for each BMP structure, loggers were asked to indicate if they had used these structures during their harvesting operations. Loggers in this sample reported that the most frequently implemented water quality structure was a water turn-out (97%) followed by a broad base dip (85%) and a water bar (82%) (Table 4.10).

Table 4.10. Percentage of loggers in Virginia who installs water bars, broad base dips, and water turnouts on harvested sites throughout the state.

BMP structure	Implementation level (%)
Water bar	81.96
Broad base dip	84.74
Water turn-out	96.77

According to the loggers in this sample, the average per unit costs for a water bar, broad base dip, and water turn-out are \$14.92, \$28.17, and \$18.75, respectively, with median values of \$10, \$25, and \$15, respectively (Table 4.11). The primary costs of these practices were the cost of equipment time to construct the practice plus the labor to operate the machinery. A water bar has the lowest unit cost, because it is the simplest structure and it may simply reflect the higher requirements for controls on roads and less reliance on the protection of skid trails.

Table 4.11. Unit costs reported by loggers for a water bar, broad base dip, and water turnout in Virginia per practice.

Best management practice	Average cost (\$)	Median cost (\$)
Water bar	14.92	10.00
Broad base dip	28.17	25.00
Water turnout	18.75	15.00



Cubbage and Lickwar (1991) reported that the unit BMP costs for a water bar and a broad base dip were \$20 and \$40 each, respectively. Adjusting these values to 1994 dollars shows a cost of \$19.35 and \$38.70 for a water bar and a broad base dip, respectively. In this study, loggers indicated the unit costs to be lower. This is important to note because the Virginia loggers could potentially have biased the study by reporting large or inflated values, in hopes of recovering some of the costs in the form of lower stumpage value or higher delivered prices. However, when comparing these numbers with the Cubbage and Lickwar (1991) study, it is apparent that the Virginia loggers did not inflate their cost estimates in this survey. No studies analyzing water turn-outs were found in the literature.

In addition to the unit costs, respondents were asked to give the time required for constructing the various BMPs. Both cost estimates and time were requested because some loggers in the survey might have higher operating costs, and the amount of time required to construct a particular BMP could vary. The type of equipment and operating skills can vary greatly among the loggers surveyed. Therefore, it is important to look at the time for construction as well as the type of equipment used to implement each practice.

Loggers reported an average of 18 minutes to construct a water bar, 26 minutes to construct a broad base dip, and 16 minutes to construct a water turn-out, with median values of 15, 20, and 15 minutes respectively (Table 4.12).

Table 4.12. Time loggers required for constructing a water bar, broad base dip, and water turnout in Virginia.

Best management practice	Average time (minutes)	Median time (minutes)
Water bar	18	15
Broad base dip	26	20
Water turn-out	16	15

Loggers reported only a two minute difference in the time required to construct a water bar and a water turn-out. A broad base dip required 8 more minutes than a water bar and 10 more minutes than a turn-out. The time differences can be attributed to the complexity of the structure, site conditions, operator skills, and equipment type used to construct the structure. These factors can lead to the differences in costs for each practice. Note that loggers in the survey viewed their reported estimates of time and cost for each practice as low cost activities.

Timber harvesters were also asked to report the type of equipment that was used to construct each practice. The type of equipment has an impact on the cost of each practice. For example, the cost of installing a water bar might be different if a logger uses a bulldozer versus a skidder for implementation. Therefore, reporting the type of equipment used for installation helps establish actual costs.

During harvesting operations, a bulldozer is used to build access roads, clear the loading area and construct major skid trails for the harvesting operation. A skidder is used to bring the felled trees from the stumps to the central loading area. Although

most skidders have a blade attached that allows them to move piles of limbs and small mounds of dirt, their primary purpose during the harvesting operation is to skid felled trees to the loading area. Since a skidder is not as efficient as a dozer in moving mounds of dirt, it can take longer to construct a water bar with a skidder as compared to a dozer. Thus, the type of equipment can have an impact on the cost of each BMP.

Loggers use a bulldozer more frequently than a skidder to construct water bars (53%), broad base dips (72%) and water turn-outs (63%) (Table 4.13). This is what should be expected since the dozer is more efficient for constructing turn-outs and broad base dips to divert water from the haul road surface. The dips and turn-outs still allow vehicular traffic to use the road.

Table 4.13. Type of equipment most frequently used to construct a water bar, a broad base dip, and a water turn-out.

Structure	Skidder (%)	Dozer (%)
Water bar	47	53
Broad base dip	28	72
Water turn-out	37	63

An approximately equal number of loggers use a skidder as use a bulldozer to construct water bars to divert water from skid trails. Water bars are usually constructed after the skid trail is no longer needed. By the time the water bars are constructed, the bulldozer may have been moved to another site to begin constructing

access roads and loading areas. Frequently, a skidder is the only piece of equipment left on the site to construct water bars.

### **Streamside Management Zone**

A streamside management zone (SMZ) is "An area of 50 feet or more on both sides of the banks of perennial streams and bodies of open water ...to protect bank edges and water quality," as defined by the Virginia BMP manual (Virginia Department of Forestry 1989). The purpose of the SMZ is to provide an undisturbed zone to filter sediments before they enter the body of water.

SMZs are recommended for all perennial streams, lakes, ponds, natural springs, and reservoirs that serve as water sources for domestic use. The width of the SMZ varies according to slope, vegetation, and type of water source. For example, on slopes between 0 and 10 percent, recommended minimum widths for the SMZ of 66 feet for trout streams, 50 feet for warm water fisheries, and 100 feet for municipal water supplies.

In the questionnaire, loggers were asked if they designated SMZs on harvested sites for perennial streams. A perennial stream is defined as a stream that flows the majority of the year and one that is indicated by a solid blue line on United States Geological Survey 7.5 Minute Series (topographic) quadrangle maps.

Loggers were also asked if SMZs were used for intermittent streams on harvesting operations. An intermittent stream is a stream or portion of a stream that flows only in response to precipitation. It is generally dry for a large portion of the

year. It is identified as a dashed blue line on topographic maps.

In Virginia, 77.4 percent of the loggers designated the SMZs along perennial streams on harvest sites, and 70 percent designated SMZs along intermittent streams. Of the timber harvesters who designated SMZs, 56 percent flag the SMZ prior to harvest with the remaining 44 percent flagging the SMZ during the harvest operation.

Within an SMZ, a partial harvest of the timber is allowed. However, when cutting within an SMZ, a minimum of 50 percent crown cover or 50 square feet of basal area must remain after the harvest. Of the loggers in the sample who responded to the questionnaire, 81 percent had harvested individual trees within the SMZ.

Fifty percent of the loggers who harvested within an SMZ indicated that harvesting costs increased when individual trees were harvested within the SMZ. Fourteen percent reported a drop in harvesting costs, while thirty six percent saw no change. In Virginia, BMP guidelines prohibit clearcuts that remove all merchantable trees from the SMZ harvest areas. Removing individual trees is allowed within the SMZ as long as the residual stocking levels are met. Because of the cutting restrictions, a timber harvester can experience an increase in the harvesting costs within an SMZ. If a timber harvester typically performs clearcuts, the harvesting methods within the SMZ must change. The change can be as simple as the felling method, manual versus mechanical, or as severe as hiring specialized cutters to harvest within the SMZ. These additional requirements usually cause the harvesting costs to increase.

On the average, an SMZ costs \$78.25 and requires 3 additional hours of work. The cost is dependant on the length of the SMZ and whether or not both sides of the stream must be flagged. The costs reported by loggers include the costs of supplies and labor needed to designate the SMZ as well as the increased costs for harvesting within the SMZ. The median values according to loggers were a cost of \$75.60 and required 2.9 hours. As noted above, loggers in the survey viewed the SMZ as a low cost activity.

### **Stream Crossings**

In Virginia, three types of stream crossings are recommended. They are pipe culverts, bridges, and fords. The crossing should be installed perpendicular to the direction of the stream flow. In the sample, 74 percent of the loggers have used culverts, 30 percent have used fords, and 27 percent have used bridges. These percentages total to more than 100 percent because a logger could have used more than one stream crossing method. Loggers have used either a skidder, bulldozer, backhoe, or front end loader, depending on site conditions, when constructing the stream crossings.

A pipe culvert is a hollow device that allows surface water to flow under the road or skid trail surface. Pipe culverts may be made of steel, aluminum, concrete, or plastic. The culvert size needed is a function of the number of acres that are drained, the slope of the site, and the soil type. Once the culvert is placed in the stream channel, earth (dirt) is compacted over it to allow traffic to cross.

Twenty-two loggers in the sample used a skidder to install a culvert, 34 used a dozer, 12 used a back-hoe, and eight used a front end loader. Several loggers used two or more types of equipment, depending on site conditions.

A bridge is a structure that supports a road or skid trail which operates over a stream or other depression. Bridges are generally installed on sites where culverts cannot handle the flow of water, or over ravines that are unlikely to be filled in with the road material.

Temporary bridges are typically used during a timber harvesting operation. Once the harvesting operation is completed, the logger moves the bridge to the next harvest site. Pre-manufactured portable bridges are frequently seen on harvest sites throughout Virginia. To install a temporary, portable bridge, 12 loggers used a skidder, 11 used a dozer, four used a back-hoe, and eight used a front end loader.

A ford is a natural stream crossing where the traffic passes directly over the floor of the stream bed. This type of crossing is recommended for haul roads only and only under certain site-specific conditions. Since the stream bed is used directly as the road surface, its floor must be hard (rocky) enough to support the traffic. In some areas, sand fords are possible.

To install a ford, a logger usually grades the roadway entrance and exit into the stream. Gravel is often placed on either side of the crossing to dissipate water from the road surface. In the survey, ten loggers used a skidder to install a ford, twelve used a bull dozer, and one used a back-hoe.

According to the loggers, a culvert costs an average of \$237.90 and requires

2.5 hours to install. The cost of a culvert will, of course, depend on its size (diameter) and length. A ford costs an average of \$196.30 and takes 2.4 hours to construct. One bridge costs an average of \$929.00 and requires 9.4 hours to install (Table 4.14). The bridge cost will depend on its length and type of material used (e.g., wood, concrete, or steel). Thirty-three loggers in the sample indicated that these costs are relatively low, but twenty-four loggers viewed costs of stream crossings as a high cost practice (Table 4.6).

Table 4.14. The time and cost required when using a culvert, bridge, or ford during timber harvesting operations reported by loggers in Virginia.

Stream crossing	Average		Median	
	Cost (\$)	Time (hours)	Cost (\$)	Time (hours)
Culvert	237.90	2.5	200.00	2.0
Ford	196.30	2.4	150.00	2.0
Bridge	929.00	9.4	737.00	7.0

Cubbage and Lickwar (1991) analyzed the cost of installing a culvert for a stream crossing in Georgia and reported the base cost to be \$420 per culvert. This was adjusted for the effects of inflation to \$409.39 in 1994 dollars, per culvert plus the cost of the culvert. The base cost in the Cubbage and Lickwar (1991) study included the labor and equipment expense for installing the culvert. By contrast, loggers in Virginia reported that the cost of installing a culvert to be approximately one-half of



the costs reported in the Georgia study. Perhaps the base cost might be inflated in the Georgia study, because installation costs are considered separately from the cost of culvert. In this study, loggers were asked to report the cost of a culvert, including installation costs.

Culverts and fords require about the same amount of time for installation. The difference in their unit costs can be attributed to the cost of the pipe, whose diameter will vary with the size of the watershed being drained. The large cost of a temporary bridge can be attributed to the materials and labor associated with building and installing it.

### **Site Stabilization**

Revegetation of disturbed soil is recommended to stabilize sites in order to prevent erosion and to reduce sediment runoff. Log decks, skid trails, and access roads are areas that, through the harvesting process, expose bare soil. In Virginia, seeding is recommended on grades of 5 percent or greater.

According to loggers, the cost for site stabilization in the state averaged \$308 per tract harvested with a median value of \$300. This cost includes grass seed, fertilizer, and mulch. The time required for site stabilization averaged 7.3 hours with a median value of 7 hours. Seventy-three percent of the loggers surveyed said that site stabilization required additional equipment such as a tractor, disc, tiller, and/or seeder.

The cost for site stabilization reported by loggers is treated as a fixed cost. The costs of grass seed, fertilizer, and mulch are a function of the amount of area of

bare soil exposed. Since decks and major skid trails contain most of the bare soil area on a harvested site, it seems appropriate to determine the costs of stabilizing the average sized deck and associated skid trails. Once the average deck cost is determined, the cost of stabilization can be calculated based on the number of decks used per site during the harvesting operation.

Based on the authors experience, the average deck size plus in Virginia is 0.2 acres. The BMP guidelines for revegetation of bare soil recommends 40 pounds per acre of seed, 600 pounds per acre of fertilizer, and 1.5 tons of mulch per acre. Material costs are \$0.70 per pound for seed (fescue), \$185 per ton for fertilizer, and \$60 per ton of mulch.

To prepare the deck and skid trails for seeding, loggers indicated that they scarified the earth with either a disk, rake, or ripper to loosen the soil. Depending on the length of major skid trails to the deck, it should take 2 to 4 hours to prepare the soil for seeding. Combined machine rates and labor costs for this activity were assumed to be \$63 per hour. Using the median value of 3 hours, the labor and machine costs were \$189 per deck. Therefore, the total cost for seeding one deck was estimated to be \$268.

### **Logger Training**

One of the main thrusts of Virginia's water quality program has been to educate loggers about the need to follow the BMP guidelines. In the sample, sixty-three percent of the loggers reported having attended BMP training (Table 4.15).

Table 4.15. Loggers in the sample who have attended a BMP workshop sponsored by the Virginia Department of Forestry, Virginia Tech, forest industry, or the U.S. Forest Service.

Coastal plain (%)	Piedmont (%)	Mountain (%)	State total (%)
50	60	73.7	62.9

Loggers reported that 50 percent of loggers in the coastal plain region, 60 percent in piedmont region, and 73 percent in the mountain region had attended a BMP workshop. The state percentage was calculated by collapsing the regional totals, and then dividing by the number of participants. This indicates that in areas where BMPs are most important and where they can be the most difficult, loggers have been trained to properly install BMPs.

According to the survey responses, loggers noted that they are responsible for constructing BMPs on harvested sites more frequently than is the timber buyer or a BMP contractor (Table 4.16). The duplication in these results suggest that although a logger may typically be responsible for BMPs, he occasionally will harvest a tract where the timber company has accepted responsibility for constructing BMPs.

Table 4.16. Individuals or firms who generally construct BMPs on harvested tracts in Virginia.

Region	Logger (%)	Timber buyer (%)	BMP contractor (%)
Coastal plain	75	38	25
Piedmont	81	36	6
Mountain	95	11	0
State total	84	29	6

### Case Study

The survey responses of the regional unit costs of BMPs showed that there were no significant regional differences, with the exception of haul road construction. This does not mean, however, that the per acre costs for implementing BMPs are equal for harvested tracts in each region.

The three physiographic regions of Virginia are distinguished by differences in timber types, market conditions, soil composition, and slope. Depending upon these differences, the numbers of each water quality practice that are required to satisfy the BMP guidelines will likely vary among the regions.

Forty-six recently harvested sites were visited to determine the numbers of each type of BMP that had been used during the actual harvesting operations. The sites were randomly selected from harvesting operations completed in Virginia from November 30, 1994, until November 30, 1995. Of the 46 sites, 19 were located in the coastal plain, 15 in the piedmont, and 12 in the mountain region. Each site was

visited to determine the numbers of each type of BMP that was used in the harvest (Table 4.17, Table 4.18, and Table 4.19).

For the purpose of this study, it was assumed that all of the harvested sites in this study had some form of pre-harvest planning. The data for SMZs represents the number used during the harvesting operation, not the size or width of the SMZ.

When determining the costs incurred by the logger for seeding and site stabilization, it is important to calculate costs actually incurred by the logger. To arrive at a logger's stabilization cost, the number of decks seeded after harvest was used. The data under the column titled "Number of decks" represents the number of decks that were seeded, not the number actually used during the harvest operation. For example, a particular site might have used four decks to remove the timber, but after the harvest, only one deck was stabilized and seeded. Although the logger used all four decks during the harvest, he incurred stabilization costs on only one deck.

The "Length of the access" columns represents the distance from the landing to a state maintained road. Loggers are responsible for installing and maintaining BMPs on this portion of the road during the harvest operation. On a few harvested sites in each region, loggers located the decks adjacent to a state maintained road. If this was the case, loggers were not responsible for an access road which is reflected by a zero in this column in Tables 4.17, 4.18, and 4.19.

As expected, the mountain region had the highest number of BMPs per tract, followed in order by the piedmont and coastal plain regions (Table 4.17, Table 4.18, and Table 4.19). In all of the regions, the most frequently used structure was the

Table 4.17. Number of each type of BMP used during the harvest, listed by tract for the coastal plain region.

Size of tract (acres)	Pre-harvest planning (yes/no)	Broad base dips (#)	Water turn-out (#)	Water bar (#)	Culvert (#)	Ford (#)	Bridge (#)	SMZ (#)	Number of decks (#)	Length of access (feet)
125	yes	1	7	0	1	0	0	1	0	17,094
55	yes	0	0	0	0	0	0	0	0	500
140	yes	0	3	0	0	0	0	1	0	3,168
125	yes	1	3	0	0	1	0	1	0	2,600
122	yes	0	0	0	0	0	0	1	0	16,400
20	yes	0	2	0	2	0	0	0	0	2,500
89	yes	0	0	30	0	0	0	1	0	2,970
60	yes	0	0	0	0	0	0	0	0	1,000
17	yes	0	0	2	0	0	0	1	0	1,250
150	yes	0	3	3	0	0	0	1	0	6,600
25	yes	0	0	0	2	0	0	0	0	0
168	yes	0	0	0	0	0	0	1	0	0
505	yes	0	0	0	5	1	1	1	0	0
194	yes	0	0	0	0	0	0	0	0	6,000
140	yes	0	0	0	0	0	0	1	0	0
65	yes	0	0	0	0	0	0	0	0	1,200
20	yes	0	0	0	0	0	0	1	0	0
56	yes	0	0	0	0	0	0	1	0	4,000
80	yes	0	0	0	0	0	0	0	0	0

Pre-harvest planning - assumes that all harvested tracts had some form of pre-harvest planning.

Number of decks - represents the number of decks seeded; not the number of decks used during the harvest operation

Length of access - indicates the length of the haul road from the deck to a state maintained road.

Table 4.18. Number of each type of BMP used during the harvest, listed by tract for the piedmont region.

Size of tract (acres)	Pre-harvest planning (yes/no)	Broad base dips (#)	Water turn-out (#)	Water bar (#)	Culvert (#)	Ford (#)	Bridge (#)	SMZ (#)	Number of decks (#)	Length of access (feet)
44	yes	0	5	0	0	0	0	0	3	3,700
28	yes	0	1	1	0	0	0	1	4	4,690
43	yes	0	0	10	1	0	0	1	0	2,970
80	yes	0	0	25	0	0	0	0	4	4,000
12	yes	0	0	0	1	0	0	1	0	1,200
207	yes	0	7	8	0	0	2	1	2	6,300
127	yes	0	0	8	0	0	0	1	7	5,000
30	yes	0	6	9	0	1	1	1	1	0
33	yes	3	11	0	5	0	0	1	0	0
60	yes	0	3	39	2	0	0	1	1	0
6	yes	0	0	8	0	0	0	1	0	705
18	yes	0	0	0	0	0	0	0	0	0
60	yes	0	0	0	0	0	1	0	1	2,025
23	yes	0	0	0	0	0	0	1	1	0
45	yes	0	0	0	0	0	0	0	0	675

Pre-harvest planning - assumes that all harvested tracts had some form of pre-harvest planning.

Number of decks - represents the number of decks seeded; not the number of decks used during the harvest operation

Length of access - indicates the length of the haul road from the deck to a state maintained road.

Table 4.19. Number of each type of BMP used during the harvest, listed by tract for the mountain region.

Size of tract (acres)	Pre-harvest planning (yes/no)	Broad base dips (#)	Water turn-out (#)	Water bar (#)	Culvert (#)	Ford (#)	Bridge (#)	SMZ (#)	Number of decks (#)	Length of access (feet)
15	yes	0	0	0	0	0	0	1	2	1,500
20	yes	0	0	12	0	0	0	0	1	8,975
20	yes	8	1	0	0	0	0	0	1	7,000
25	yes	3	0	11	0	0	0	1	2	990
44	yes	0	0	1	0	0	0	1	2	600
15	yes	0	0	0	0	0	0	0	0	900
200	yes	0	0	200	2	0	1	0	0	1,056
100	yes	0	2	1	1	0	0	1	4	0
90	yes	5	10	22	0	0	1	2	3	3,000
32	yes	25	15	27	2	0	0	1	2	5,045
90	yes	0	0	0	0	0	0	0	3	0
44	yes	0	10	0	0	0	0	0	2	0

Pre-harvest planning - assumes that all harvested tracts had some form of pre-harvest planning.

Number of decks - represents the number of decks seeded; not the number of decks used during the harvest operation

Length of access - indicates the length of the haul road from the deck to a state maintained road.



water bar. Broad base dips and water turn-outs, which are commonly used for access roads, were more common in the mountain region than in the other two regions. Each region had a similar proportion of sites with SMZs and with decks located adjacent to the state road. A majority of the tracts in the mountain and piedmont regions were seeded, but no tracts were seeded in the coastal plain region.

The per unit costs reported earlier were used to determine the total cost of the BMPs implemented on each harvested site. Except for the cost of road construction, the state median cost of each BMP was used to calculate the total cost per acre because median values are less likely to be influenced by extreme values (Table 4.20).

Table 4.20. Virginia per unit costs for BMP water quality practices.

BMP	Unit cost (\$)
Pre-harvest planning	3.17 per acre
Broad base dip	25 per dip
Water turn-out	10 per turn-out
Water bar	15 per bar
SMZ	1.20 per acre
Culvert	200 per culvert
Bridge	737 per bridge
Ford	150 per ford
Seeding	268 per deck

For road construction costs, median values of the additional costs of following BMP guidelines for haul road construction were used in the appropriate region (Table 4.21). Once the total cost per BMP was determined, the per acre cost was calculated incorporating all BMPs.

Table 4.21. The additional cost per mile for following BMP guidelines in the three physiographic regions of Virginia.

Physiographic region	Road cost per mile (\$)
Coastal plain	649
Piedmont	665
Mountain	801

The results for BMP implementation are reported by regional per acre cost. The results are also analyzed for the effects of access road, tract size, and SMZ on the per acre averages.

To determine the average cost per acre, the individual tract total was calculated first. Tract totals were based on the number of BMPs for each region (Tables 4.17, 4.18, and 4.19) times their per unit costs (Tables 4.20 and 4.21). The average cost per harvested acre for each tract was determined by dividing the total cost by the number of acres per tract harvested. To get the regional average, the tract averages for a region -- coastal plain, piedmont, and mountain -- were averaged by tract size.

### **Including Road Construction Costs**

The average cost for implementing BMPs on harvested sites are first examined including road construction costs and then with road construction costs excluded. With road construction costs included, the average cost was \$9.57 per acre in the coastal plain region, \$25.47 per acre in the piedmont region, and \$30.18 in the mountain region (Table 4.22). The median values were \$8.11 in the coastal plain region, \$25.75 in the piedmont region, and \$29.29 in the mountain region (Table 4.22).

Table 4.22. The cost per acre of BMPs, including road construction costs, in each region of Virginia.

Region	Minimum (\$)	Maximum (\$)	Average (\$)	Median (\$)
Coastal plain	3.17	39.53	9.57	8.11
Piedmont	3.17	64.64	25.47	25.75
Mountain	12.10	94.41	30.18	29.29
State	3.17	94.41	17.02	18.90

The highest costs per acre for implementing water quality practices occurred in the mountain region where they varied from \$12.10 to \$94.41 per acre. This wide range results from some tracts having only minimum requirements for BMPs (see Table 4.19). The wide differences in BMP implementation costs can be attributed primarily to the greater number of practices required in the mountain region.

In 1991, Cabbage and Lickwar reported that the cost of BMPs in Georgia were

\$32.90 in the mountain region, \$22.43 in the piedmont region, and \$8.62 in the coastal plain region. If Cubbage's and Lickwar's (1991) values are adjusted for inflation to 1994 dollars, they show an estimated cost of \$31.80 in the mountain region, \$21.70 in the piedmont region, and \$8.34 in the coastal plain region. Since Cubbage's and Lickwar's study included the cost of haul road construction, their results for Georgia are similar to the costs for each region of Virginia. The Cubbage and Lickwar (1991) study, however, determined the cost of implementing all required BMPs on the harvested site. For this Virginia study, the costs were determined based on the number of BMPs actually implemented and constructed during the harvesting operation.

Of the 46 case study sites visited in this study, 90 percent were harvested without a water quality problem due to improper use of BMPs. But only 13 percent of the tracts in this study met all technical specifications -- that is 100 percent compliance with the BMP manual (Austin 1995). For example, if the site had an adequate number of water bars, but the spacing was incorrect, the tract failed to meet total technical compliance, but the logger did incur BMP costs during the harvesting operation. If strict regulatory compliance were required in implementing BMPs on each tract, the per acre costs would have been much higher.

### **Excluding Road Construction Costs**

Since BMP-related haul road costs contributed such a large component of total cost, the BMP were evaluated without haul road costs. Excluding the cost of haul road construction reduced the per acre cost in the mountain region to \$23.83 (Table

4.23). The piedmont cost of BMPs dropped to \$20.75 per acre, and the coastal plain region cost dropped to \$5.85 per acre. The median values were \$24.72 in the mountain region, \$21.04 in the piedmont region, and \$4.37 in the coastal plain region (Table 4.23)

Table 4.23. Costs of BMPs, excluding haul road construction costs, by each region of Virginia, per acre.

Region	Minimum (\$)	Maximum (\$)	Average (\$)	Median (\$)
Coastal plain	3.17	24.17	5.85	4.37
Piedmont	3.17	49.37	20.75	21.04
Mountain	3.17	70.50	23.83	24.72
State	3.17	70.50	12.57	15.51

The costs of BMPs excluding haul road construction show a decrease in the cost of complying with BMPs. The trend displayed when haul road costs were included was still evident, however, with higher BMP costs still found in the mountain region followed in order by the piedmont and coastal plain. Since the number of water quality practices differs within each region, the difference in regional costs was directly related to the number of practices needed per harvested site.

## Tract Size

Tract size can have an impact on the per acre harvesting costs; therefore, the total BMP costs were analyzed by tract size. Based on the number of sites, a comparison was made between large and small tracts. Large tracts were parcels larger than 75 acres in size, and all others were considered small tracts. Ideally, it would be beneficial to make the comparison among small, medium, and large tracts, but the sample size was too small for this type of analysis.

The small tracts had a higher cost per acre in each region (Table 4.24) than large tracts (Table 4.25). This suggests that on larger tracts, loggers were able to spread the total costs over more acres, which reduced the per acre costs. Small harvest operations do not allow this flexibility. This is consistent with Row's study (1978) which reported that small tracts have a higher operating cost than large tracts.

Table 4.24. BMP costs for small tracts, including road BMP costs, by physiographic region of Virginia, per acre.

Region	Minimum (\$)	Maximum (\$)	Average (\$)	Median (\$)
Coastal plain	4.29	39.53	10.23	9.30
Piedmont	3.17	64.64	28.61	29.46
Mountain	12.27	94.41	47.24	48.35
State	3.17	94.41	26.62	24.96

The difference in median costs between large and small tracts were \$1.19 in the coastal plain region, \$4.41 in the piedmont region, and \$27.48 in the mountain region.

Tract size has a greater influence in the mountain region of Virginia.

Table 4.25. BMP costs for large tracts including road BMP costs by physiographic region of Virginia, per acre.

Region	Minimum (\$)	Maximum (\$)	Average (\$)	Median (\$)
Coastal plain	3.17	23.54	9.46	8.11
Piedmont	18.83	27.55	22.42	25.05
Mountain	12.10	33.92	22.54	21.05
State	3.17	33.92	13.72	12.82

Note that for large tracts, there was little difference in the average per acre cost between the mountain and piedmont regions. When considering the median values, mountain region costs are actually less than piedmont region costs. These results may be attributed to the small sample size in each region: three large tracts in the piedmont and only four large tracts in the mountain region.

This same trend was present when the per acre costs were analyzed excluding road BMP costs. The data showed that there was a difference in per acre BMP costs between large and small tracts throughout Virginia.

### **Streamside Management Zones**

SMZs had an affect on BMP costs. Tracts harvested with an SMZs had a higher per acre cost in all three regions when compared with the tracts that did not have SMZs (Tables 4.26 and 4.27). The cost differences were \$3.99 in the coastal

plain region, \$5.52 in the piedmont region, and \$16.93 in the mountain region.

Table 4.26. The regional cost of implementing BMPs on harvested tracts with streamside management zones, including road BMP costs, per acre.

Region	Minimum (\$)	Maximum (\$)	Average (\$)	Median (\$)
Coastal plain	4.37	23.54	10.18	9.43
Piedmont	16.02	64.64	26.65	29.69
Mountain	12.27	94.41	35.62	37.67
State	4.37	94.41	16.74	19.86

Table 4.27. The regional cost of implementing BMPs on harvested tracts without SMZs, including road BMP costs, per acre.

Region	Minimum (\$)	Maximum (\$)	Average (\$)	Median (\$)
Coastal plain	3.17	39.53	7.57	5.44
Piedmont	3.17	27.55	22.76	24.17
Mountain	12.10	93.65	27.34	20.74
State	3.17	93.65	17.57	18.29

As expected, the average cost per acre for tracts with SMZs was higher than the regional averages. This data revealed that the added costs of SMZs on harvesting operations was significant.



## **Summary**

Two hundred seventy-two loggers in Virginia were surveyed to determine their perception of BMPs costs and their estimated BMP costs per unit. Sixty four agreed to participate and returned their questionnaires. All participants were loggers who frequently harvest timber within Virginia. The loggers responded to a series of questions concerning pre-harvest planning, road location and construction, broad base dips, water turn-outs, water bars, SMZs, stream crossings, site stabilization, and BMP workshops. At the conclusion of the survey, loggers ranked each practice according to the cost and difficulty in implementation. They were grouped according to the region in which they predominately harvested -- coastal plain, piedmont, or mountain region. Regional averages of each cost per unit were compared to see if there were significant differences. With the exception of haul road construction, there were no significant regional differences in costs per unit for BMP practices.

Forty-six harvested sites in Virginia were visited to determine the number of each type of BMP implemented during the harvesting operation. Twelve sites were located in the mountain region, 15 in the piedmont region, and 19 in the coastal plain region.

Using the state costs per unit and regional road construction costs, along with the numbers of each BMP used on the harvest site, the total cost of implementing BMPs on each tract was determined. The cost per acre was then calculated based on the number of harvested acres.

The study results showed that the costs of BMPs in Virginia were highest in the mountain region, followed in order by the piedmont and coastal plain regions. The difference in regional BMP costs per acre is directly related to the number of practices required to meet the BMP guidelines.

Tract size and the presence of a SMZ had an impact on BMP costs per acre. Large tracts, greater than 75 acres, had a lower BMP cost per acre than small tracts. Similarly, tracts without SMZs had a lower BMP cost per acre than tracts with SMZs.

Of the 46 case study sites visited in this study, 90 percent were harvested without a water quality problem due to improper use of BMPs. But only 13 percent of the tracts in this study met all technical specifications according to the BMP manual. If strict regulatory compliance were required in implementing BMPs on each tract, the per acre costs would have been much higher.

Generally, the loggers in the sample viewed the cost of individual BMPs as a low cost activity. This does not necessarily imply that loggers view the BMP program in Virginia as a low cost activity. It can be concluded, however, that BMP guidelines are well accepted by the logger, and that costs were probably passed back to the forest landowner in lower stumpage values.

## Chapter 5. Summary

Two hundred seventy-two loggers in Virginia were surveyed to determine the financial burden for complying with Virginia's voluntary forestry BMP program. Loggers from the three physiographic regions of Virginia -- coastal plain, piedmont, and mountain -- responded to the questionnaire. Forestry BMPs analyzed in the study included pre-harvest planning, road construction, broad base dips, water turn-outs, water bars, stream side management zones (SMZs), stream crossings, and seeding.

According to the sixty-four respondents in the survey, pre-harvest planning was the most frequently implemented practice (96.8%), followed by water turnouts (96.7%), broad base dips (84.7%), water bars (81.9%), and SMZs (77.4%).

The only significant difference in regional BMP unit costs was found in the cost of road construction. Therefore, the unit costs for all regions were combined for each practice and the state average unit BMP cost was reported, except for road construction costs which were reported separately. Loggers in the survey perceived all of the unit BMP costs as a low cost activity, relative to other operational costs.

Forty-six recently harvested sites were randomly selected and visited to determine the numbers of each BMP used during the harvest operation. Of the 46 sites, 19 were located in the coastal plain, 15 in the piedmont, and 12 in the mountain region.

Using the state unit cost along with the corresponding regional road costs and the numbers of each BMP used, the per acre cost for implementing the practices was

determined for each tract. The per acre BMP costs, including road construction, were \$8.11 in the coastal plain region, \$25.75 in the piedmont region, and \$29.29 in the mountain region.

Excluding the cost of BMP-related road construction, the costs per acre were \$4.37 in the coastal plain region, \$21.04 in the piedmont region, and \$24.72 in the mountain region. Although excluding the road costs reduced the per acre cost in each region, the cost of BMPs maintained the trend of highest cost in the mountain region and lowest cost in coastal plain region.

Tract size also had an impact on the per acre BMP cost. Large tracts, greater than 75 acres, had a lower per acre cost than small tracts. The presence of SMZs on harvested tracts also had an impact. The per acre cost for tracts with an SMZ was higher than for tracts without an SMZ. In both cases, the highest costs were found in the mountain region, followed by the piedmont and coastal plain regions, respectively.

Finally, the cost or impact of forestry BMPs to loggers and landowners cannot be adequately examined without considering the benefits the BMPs produce for society. The BMP costs are justified if they are offset by society's benefit. Unfortunately, this study provides little insight into the value of the actual benefits and their comparison to the cost of BMPs. More in-depth analysis of this subject is an important source for future research.

## **Conclusions**

Virginia's voluntary BMP program focuses on harvesting outcomes and the results show reduction in water quality problems. The current voluntary program in Virginia is attaining the goals of reducing problems associated with timber harvesting. This is evident in the decrease in the number of harvested sites that had water quality problems from 20 percent in the November 1993 audit, to only 5 percent of the sites audited in November 1995. Likewise, the number of sites that had potential water quality problems due to improper application of BMPs decreased from 47 percent in 1993, to 32 percent in 1995.

Overall, loggers in Virginia view the costs of individual BMPs as both relatively low cost and easy to implement from a production or time cost standpoint. Although the loggers were not asked their opinion on the cost of collectively applying all necessary BMPs on timber harvest sites, it seems reasonable to conclude, based on the responses to individual practices, that loggers would also view BMPs collectively as "low" cost.

With the exception of road construction costs, there were no significant regional differences in the per unit BMP costs across Virginia. The differences in regional BMP costs can be attributed to the number of practices required in each region. Because of the slope and terrain, the mountain region required the most BMPs, followed by the piedmont and coastal plain regions. As a result, the per acre BMP costs were highest in the mountain region, followed by the piedmont and coastal plain regions. Tract size also had an impact on the per acre cost, as well as SMZs.

The majority of loggers have satisfactorily implemented BMPs on harvested sites; however, only a small percentage of harvested sites throughout Virginia are in complete compliance with the BMP manual. If Virginia's voluntary program becomes regulatory in nature, such as the current status in Maryland, which requires all technical specification to be met on each site, timber harvesters in Virginia will see an increase in the cost of implementing BMPs.

Loggers are becoming more aware of reducing the impact of water quality problems. Although a small percentage of the sites met all technical specifications, the potential for a water quality problem resulting from a timber harvest is steadily decreasing in Virginia.

### **Suggestions for Further Research**

Additional analysis of the cost of water quality practices is needed. This study has analyzed the costs from the loggers perspective. Accordingly, on over 90 percent of harvested sites, an effort has been made to comply with the BMP manual. Only a small percentage of the sites, however, meet all technical BMP specifications. If loggers in Virginia are required to fully comply with the BMP manual, they could see a considerable increase in costs. An analysis of this increase would be helpful in determining the impact of changing Virginia's voluntary program to a regulatory one.

A case analysis of water quality practices using geographic information system (GIS) procedures would be helpful. Such a study of the relationship between the costs of more complete implementation of BMPs and the benefits from increasing the degree of implementation would be useful. An understanding of the spatial relationship of BMPs could better facilitate the use of preventative actions, rather than corrective actions.

The most obvious need for future research should address the question of who bears the costs of the water quality practices in Virginia. Prior to any consideration of increased regulation of water quality practices, the individual or group of individuals who will bear a majority of the costs of implementation should be identified. This will help ensure that the proposed legislation to improve the water resources will focus attention on the person(s) who are responsible for causing the problem that requires the BMPs.

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## **Appendix A.**

Virginia Department of Forestry  
Best Management Practice  
Implementation and Effectiveness Audit Sheet

Please answer all questions in a complete, thorough, and objective manner.

**BMP Effort**

1. Has an effort been made to apply BMPs whether or not technical specifications as expressed in *Forestry Best Management Practices For Water Quality in Virginia*, referred to hereafter as *The Manual*, have been met?

Yes \_\_\_\_\_ No \_\_\_\_\_

- 1.1. On a scale of 1 to 5, (1=poor,5=excellent), please rate the degree of effort applied.  
(Circle one number)

1      2      3      4      5

**BMP Implementation**

2. Were all BMPs applied to technical specifications as expressed in *The Manual*?

Yes \_\_\_\_\_ No \_\_\_\_\_

**If Yes:** Answer the questions on the **back** of this sheet.

**If No:** Continue **below and** on the **back** of this sheet.

- 2.1. Describe any discrepancy between *The Manual* and observed BMPs.  
Cite *The Manual* by page number.

- 2.2. Does a water quality **problem** exist **now** as a result of not meeting technical specifications expressed in *The Manual*?

Yes \_\_\_\_\_ (Describe the problem)

No \_\_\_\_\_

- 2.3. Does the **potential** exist for a water quality **problem** to develop as a result of not meeting the technical specifications expressed in *The Manual*?

Yes \_\_\_\_\_ (Describe the problem)

No \_\_\_\_\_

Virginia Department of Forestry  
Best Management Practice  
Implementation and Effectiveness Audit Sheet

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**BMP Effectiveness**

3. Does a water quality **problem** exist **now** because of the technical specifications expressed in *The Manual* have not been effective?

Yes \_\_\_\_\_ (Describe the problem)

No \_\_\_\_\_

4. Does the **potential** exist for a water quality **problem** to develop because the technical specifications expressed in *The Manual* have not been effective?

Yes \_\_\_\_\_ (Describe the potential problem)

No \_\_\_\_\_

March 18, 1994

(ADDRESS)

Dear (TIMBER HARVESTER),

Virginia's program for forestry best management practices (BMPs) has undergone several revisions in the past five years. It has evolved through three distinct phases as follows:

1. voluntary,
2. voluntary with inspections, and
3. voluntary with inspections and the anti-sediment law.

The BMP program with inspections has proven to be very effective and compliance rates are currently over 90 percent. However, there are some groups who still want stricter BMPs and who have the potential to increase the regulation of harvesting practices. One way of comparing the existing program with possible future programs is by measuring the costs and benefits associated with each particular program.

However, the costs of BMPs to Virginia loggers have never been determined.

Your timber harvesting operation is one of a small number in which loggers are being asked to provide estimates of time and costs for various BMPs. Your name was selected in a random sample from all loggers in the state of Virginia.

It is important that each questionnaire be completed as accurately as you can and returned as soon as possible. This will ensure that the results will truly represent the effects of BMPs on loggers in Virginia. A drawing for a \$100 U.S. savings bond will be held on April 30, 1994, for individuals who complete and return this survey.

Your response will be treated with complete confidentiality. The questionnaire has an identification number for mailing purposes only. This is so we may check your name off the mailing list when your questionnaire is returned and use it to determine the winner of the \$100 savings bond. Your name or the individual information in the questionnaire will not be reported in any way that could be used to identify you. Instead, the averages from the sample will be published in an effort to improve the understanding of the relationships between the regulatory costs loggers have to bear and the anticipated benefits of the BMPs.

Your participation is greatly appreciated. If you are not familiar with a particular BMP, please indicate why you are not familiar with that BMP and move on to the next question. A self-addressed stamped envelope is enclosed for your convenience. If you have any questions, feel free to call me at (703) 231- 7265.

Thank you for your assistance.

Sincerely,

Glen Worrell  
Graduate Research Assistant

## Questionnaire for loggers in Virginia

### WHEN ARRIVING AT THE COSTS FOR VARIOUS BMPs -- CONSIDER LABOR, MACHINE RATES, AND SUPPLIES NEEDED FOR CONSTRUCTION

1. Give the amount of time (in percent) for each area of the state in which you operate.  
\_\_\_\_\_ % COASTAL PLAIN \_\_\_\_\_ % PIEDMONT \_\_\_\_\_ % MOUNTAINS  
(East of I-95) (West of I-95 and east of Blue Ridge) (West of Blue Ridge)

2. What size tracts do you usually harvest? (please specify in acres for each of the following)  
\_\_\_\_\_ SMALLEST \_\_\_\_\_ LARGEST \_\_\_\_\_ AVERAGE

### PLEASE REPORT THE RESULTS OF YOUR OPERATIONS WITH RESPECT TO THE AREA OF THE STATE IN WHICH YOU OPERATE MOST FREQUENTLY.

3. Do you develop a preharvest plan before starting each harvesting operation? (This does not necessarily mean a written plan. It may simply include walking the tract to locate logging decks, haul roads, major skid trails, and flagging of buffer strips -- stream side management zones (SMZs) and road buffers -- prior to cutting). \_\_\_\_\_ YES \_\_\_\_\_ NO
- a. For the average tract how much time is involved in the preharvest planning process?  
\_\_\_\_\_ HOURS
- b. What do you think is the total cost involved in the preharvest planning process for the average tract?  
\_\_\_\_\_ DOLLARS
- i). Approximately what is the average cost per acre for preharvest planning per acre of timber cut? \_\_\_\_\_ \$ PER HARVESTED ACRE
4. For the average tract, what is the approximate cost per mile for haul road construction that complies with Virginia BMPs (maintain grade between 2-10 percent, locate on side slope, use of gravel or wooden mats at intersection of main highway, etc)? \_\_\_\_\_ \$ PER MILE
- a. How much time does it take to construct a haul road that it complies with Virginia BMPs?  
\_\_\_\_\_ HOURS
- b. If you did not have to use BMPs (maintain less than 10 percent grade, gravel road entrances, etc.) how much would it cost to construct a haul road that would not comply with Virginia BMPs?  
\_\_\_\_\_ \$ PER MILE
- i). How much time would it take to construct a haul road that does not comply with Virginia BMPs?  
\_\_\_\_\_ HOURS
- c. For Haul roads, do you use broad based dips to divert water from the road surface?  
\_\_\_\_\_ YES \_\_\_\_\_ NO



- i). If yes, what piece of equipment do you typically use to construct broad based dips?  
 \_\_\_\_\_ SKIDDER \_\_\_\_\_ DOZER \_\_\_\_\_ OTHER (PLEASE SPECIFY)
- ii). How much time is required to construct **one** broad based dip? \_\_\_\_\_ MINUTES
- iii). For the average site, what is the cost of constructing **one** broad based dip?  
 \_\_\_\_\_ \$/DIP
- d. Do you use water turn-outs to divert water from the road surface on haul roads?  
 \_\_\_\_\_ YES \_\_\_\_\_ NO
- i). What piece of equipment do you typically use to construct water turn-outs?  
 \_\_\_\_\_ SKIDDER \_\_\_\_\_ DOZER \_\_\_\_\_ OTHER (PLEASE SPECIFY)
- ii). How much time is required to construct **one** water turn-out?  
 \_\_\_\_\_ MINUTES
- iii). What is the cost of constructing **one** water turn-out on the average tract?  
 \_\_\_\_\_ \$/WATER TURN-OUT
- e. For the average tract, do you construct water bars on skid trails? \_\_\_\_\_ YES \_\_\_\_\_ NO
- i). What piece of equipment do you typically use to construct water bars?  
 \_\_\_\_\_ SKIDDER \_\_\_\_\_ DOZER \_\_\_\_\_ OTHER (PLEASE SPECIFY)
- ii). How much time is required to construct **one** water bar? \_\_\_\_\_ MINUTES
- iii). What is the cost of constructing **one** water bar? \_\_\_\_\_ \$/WATER BAR
- f. What do you estimate the **total** cost is for you to water-bar the average tract?  
 \_\_\_\_\_ DOLLARS PER TRACT
5. Do you flag or mark stream side management zones (SMZs) along perennial streams (solid blue line streams -- those that flow year-round)? \_\_\_\_\_ YES \_\_\_\_\_ NO
- a. If so, do you flag or mark the SMZ prior to harvest or during the harvesting operation?  
 Please check one: \_\_\_\_\_ PRIOR TO HARVEST \_\_\_\_\_ DURING HARVEST
- i). On average, how much time does it usually take to flag the SMZ? \_\_\_\_\_ HOURS
- ii). What is the average cost for flagging a SMZ? \_\_\_\_\_ \$ PER SMZ
- b. Do you leave buffer strips along intermittent streams (those that flow only part of the year)?  
 \_\_\_\_\_ YES \_\_\_\_\_ NO

c. On tracts with a SMZ, do you harvest timber within the SMZ?  
       \_\_\_\_\_ YES \_\_\_\_\_ NO

d. What method of harvesting do you use within the SMZ? \_\_\_\_\_

i). What do you estimate the percentage change in costs for the harvesting operation within the SMZ on a per unit basis (cord, MBF, etc.)  
       \_\_\_\_\_ % INCREASE \_\_\_\_\_ % DECREASE \_\_\_\_\_ NO CHANGE

6. For a typical stream crossing, please indicate which BMPs you have implemented.  
       \_\_\_\_\_ CULVERT \_\_\_\_\_ FORD \_\_\_\_\_ BRIDGE \_\_\_\_\_ OTHER (specify)

a. How much time (in hours) does it take to install the following stream crossing BMPs?  
       \_\_\_\_\_ CULVERT \_\_\_\_\_ FORD \_\_\_\_\_ BRIDGE \_\_\_\_\_ OTHER

b. How much does it cost to install the following stream crossing BMPs?  
       \_\_\_\_\_ \$/CULVERT \_\_\_\_\_ \$/FORD \_\_\_\_\_ \$/BRIDGE \_\_\_\_\_ \$/OTHER

c. Please check the piece(s) of equipment that you use to install the following:

	SKIDDER	DOZER	BACK-HOE	OTHER (specify)
CULVERT				
FORD				
BRIDGE				
OTHER				

7. What part (percentage) of your haul roads and logging decks need to be seeded, fertilized, and mulched after harvesting? (please circle one)

100%      75%      50%      25%      0%

a. For the average tract, what do you estimate the cost is for seed, fertilizer, and mulch for stabilizing roads and logging decks? \_\_\_\_\_ DOLLARS PER TRACT

i). How much time does it take to seed, fertilize, and mulch the average tract?  
       \_\_\_\_\_ HOURS PER TRACT

b. Does this practice require the use of additional equipment not generally used for timber harvesting? (e.g., broad cast seeder, tractor, etc.) \_\_\_\_\_ YES \_\_\_\_\_ NO

i). If yes, what additional equipment do you need?

8. Who usually constructs the BMPs on the tracts you harvest?  
 \_\_\_\_\_ YOU      \_\_\_\_\_ THE COMPANY YOU LOG FOR      \_\_\_\_\_ BMP CONTRACTOR

a. Have you or your logging crew attended any BMP meeting or workshop sponsored by the Virginia Department of Forestry, Virginia Tech, or Forest Industry?  
 \_\_\_\_\_ YES      \_\_\_\_\_ NO

b. If you have not attended any BMP workshop, what prevented you from attending?

9. The following BMPs are practices recommended in Virginia's Best Management Practices for Water Quality Manual. Please indicate how costly or burdensome they have been or would be to comply with for the average tract, based on your experience. You are offered five possible answers to each practice. The "no opinion, don't know" answer should be circled *only* when you have *no* opinion. Circle one number following each practice. *Please answer all lines.*

Best Management Practice	Easily implemented at little cost	Moderately difficult, moderately costly	Difficult or costly to implement	Extremely difficult, extremely costly	No opinion, don't know
Preharvest planning	1	2	3	4	5
Haul Road Location/ Construction	1	2	3	4	5
Broad Based Dips	1	2	3	4	5
Water Turn-Outs	1	2	3	4	5
Water Bars	1	2	3	4	5
Stream side management zones (SMZs)	1	2	3	4	5
Stream crossings -- culvert installation	1	2	3	4	5
Re-seeding of landings /roads -- seed, fertilizer, and mulch	1	2	3	4	5

Additional Comments:

Please return the questionnaire in the self-addressed, stamped envelope. Thank you for your time.

Dear Survey Recipient,

Your participation in our survey of costs for forestry Best Management Practices is very important. If you have not already returned the questionnaire we sent you recently, we would appreciate your doing so as soon as possible.

Thank you for your cooperation

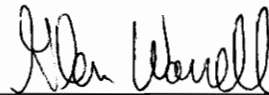
SINCERELY,

Glen Worrell  
Graduate Research Assistant  
Virginia Polytechnic Institute and State University

## Vita

The author, son of Elton and Joan Worrell, was born September 10, 1969 in Radford, Virginia. He graduated from Carroll County High School in Hillsville, Virginia in 1987 and entered the forestry program at Virginia Tech the fall of the same year. While pursuing his bachelor's degree, he participated in the Cooperative Education Program and became a member of the Society of American Foresters, Xi Sigma Pi, and Alpha Zeta. He completed his Bachelor's of Science degree in Forestry Business in May of 1992.

He entered Virginia Tech's masters program in Forest Management and Economics in August of 1992. He completed the degree of Master of Science in Forest Economics in May of 1996. The author was married to Ruth Arehart in April of 1996.



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Glen Worrell