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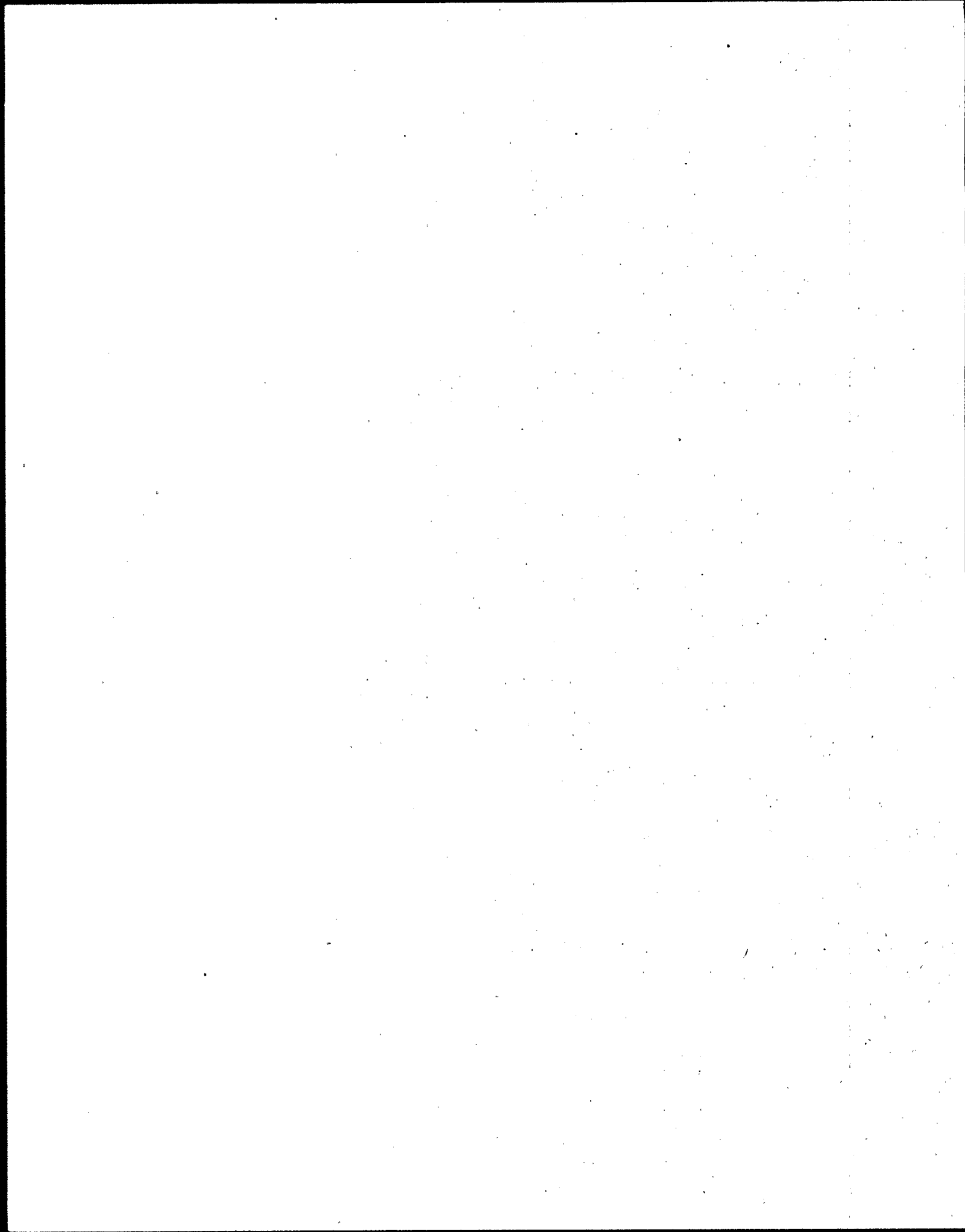
**SUMMARY OF CURRENT STATE NONPOINT SOURCE CONTROL
PRACTICES FOR FORESTRY**

AUGUST, 1993

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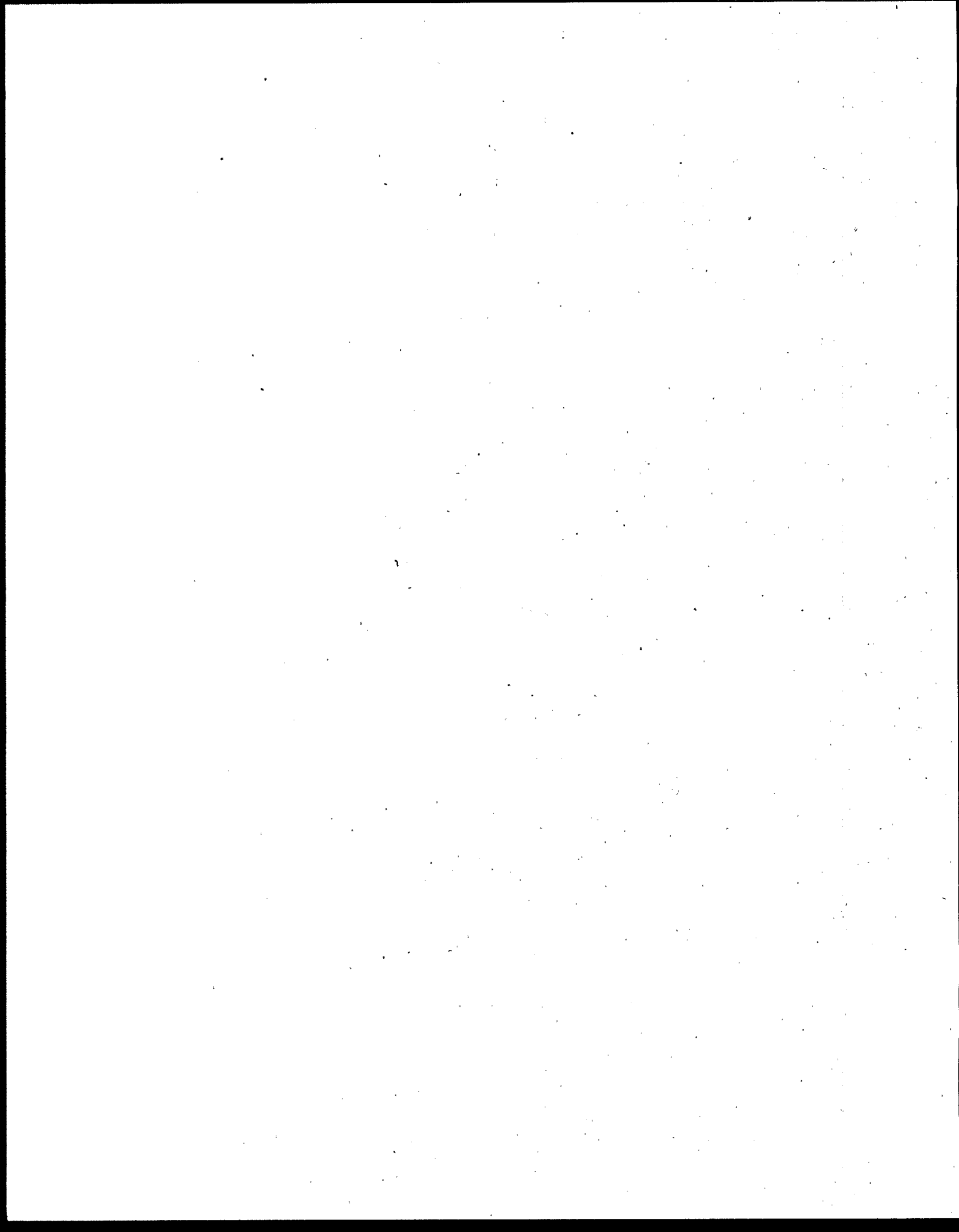


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Contents

Introduction	1
Alabama	5
Alaska	9
Arkansas	15
California	19
Connecticut	23
Delaware	25
Florida	29
Georgia	33
Idaho	37
Illinois	41
Indiana	43
Kentucky	45
Louisiana	51
Maine	53
Maryland	59
Massachusetts	67
Michigan	71
Minnesota	75
Mississippi	79
Missouri	83
Montana	87
Nevada	91
New Hampshire	93
New Jersey	97
New Mexico	99
New York	103
North Carolina	105
Ohio	111
Oklahoma	115
Oregon	119
Pennsylvania	123
Rhode Island	127
South Carolina	129
Tennessee	131
Texas	135
Vermont	139
Virginia	143
Washington	147
West Virginia	157
Wisconsin	161
Wyoming	163
Appendix A	A-1
Appendix B	B-1

Tables

Number		Page
1	Recommended Diameters for Culverts	6
2	Spacing Distances Between Diversion Devices	6
3	Riparian Standards	11
4	Spacing Guide for Drainage Structures	24
5	Recommended Filter Strip Widths	24
6	Site Sensitivity Classification	29
7	Maximum Spacing of Drainage Structures	30
8	Streamside Management Zone Widths Based on Regional Differences	33
9	Minimum Standing Trees per 1000 Feet	38
10	Minimum Buffer Widths for Chemical Applications	40
11	Drainage Dip Spacing	43
12	Water Break Spacing	44
13	Potential Site Preparation Impacts on Water Quality	47
14	SMZ Widths	48
15	Broad-Based Dip Spacing	54
16	Filter Strip Widths	54
17	Skid Hump Spacing	55
18	Water Bar Spacing	55
19	Cross Drainage Culvert Spacing	56
20	Required Buffer Widths	61
21	Required Water Bar Spacing	67
22	Filter Strip Widths	68
23	Recommended Buffer Widths	80
24	Recommended Primary and Secondary Filter Strip Widths	84
25	Maximum Distances Between Water Breaks	92
26	Buffer Strip Widths	99
27	Recommended Minimum SMZ Widths	106
28	Filter Strip Widths	124
29	Recommended SMZ Widths	133
30	Protective Strip Widths	141
31	Water Bar Intervals	144
32	Recommended SMZ Widths for Various Waters	145

INTRODUCTION

The potential for forestry activities to contribute to nonpoint source (NPS) pollution of streams, rivers, lakes, and other water bodies has been the subject of extensive study (USEPA 1993). On a national level, recent survey reports indicate that silvicultural activities contribute approximately 3 to 9 percent of the total NPS pollution (Neary et al. 1989; USEPA 1992a). Twenty-four states have identified silviculture as a source contributing to NPS pollution in their lakes and rivers (USEPA 1992b). Without adequate planning and nonpoint source controls, water quality impacts associated with forestry activities can occur. These impacts include sedimentation, nutrient and pesticide contamination, reduced dissolved oxygen levels, increases in water temperature, and changes in the magnitude and duration of stream flow.

The summaries presented in this document are intended to provide a synopsis of the Best Management Practices (BMPs) currently used by states to address the NPS impacts on water quality caused by forestry activities. This document is intended to provide the reader with general information on the component practices contained in existing state programs for forestry NPS control. The summaries are descriptive in nature and are not intended to be reviews or evaluations of the state BMPs for forestry or state NPS programs. Since no review or evaluation of state BMP program comprehensiveness, extent of implementation, or effectiveness was conducted, inclusion of a state's BMPs in this document does not represent or imply Environmental Protection Agency approval or sufficiency of the practices or state programs described.

The information in this document is intended to provide an increased understanding of the

types of forestry activities commonly addressed in existing state NPS programs and to serve as a reference for the type and nature of BMPs included in current state BMP manuals. For example, the summaries may provide information on additional practices useful to state agencies that are evaluating and enhancing their NPS programs to meet the objectives of the Coastal Zone Act Reauthorization Amendments of 1990 for management measures to control NPS pollution.

This document summarizes 41 existing state BMP manuals or regulations that include BMPs. Three other BMP manuals are being developed but were not at a stage suitable for inclusion in this summary document. The summaries in this document were developed in cooperation with the National Association of State Foresters (NASF) and include information obtained from NASF surveys of state forestry programs. Each state summary was made available for review by the appropriate state agency, and comments received were incorporated into the document. Since some states are engaged in the process of developing BMPs for forestry or are revising their existing programs, lack of representation of a given state program or practice in this document does not necessarily imply that forestry NPS controls are not being developed or addressed in that state.

Because the summaries do not provide all of the design criteria and technical information presented in the source manuals and rules, this document should not be used for field implementation of practices or evaluation of the appropriateness of state practices for a given activity. If such a level of detail is required, the reader should obtain the source documents from the state contacts included in each summary.

Many state BMP manuals and rules present a variety of additional practices not directly related to the protection of water quality, such as methods to improve timber production and procedures for maintaining aesthetics while harvesting timber. The summaries of NPS practices in this document do not include a discussion of these other aspects of state programs since they are not directly related to protecting water quality.

The information in this document is intended for use by agencies or organizations with interests in or responsibilities for forestry activities, NPS pollution control, watershed protection projects, and similar concerns. Each summary follows the general outline presented in the specific BMP manual produced by a state. Some tables from the BMP manuals are included where the information is particularly valuable to the summary. In most cases, however, the summaries make reference to figures and tables provided in the BMP manuals but do not include them. As part of each state summary, a contact person and a list of related informational materials, such as documents, brochures and videos available from the state, are provided.

OVERVIEW

Most of the BMP manuals or state regulations address the following forestry operations and management activities:

- Preharvest planning
- Road construction and maintenance
- Timber harvesting
- Streamside management zones
- Site preparation
- Chemical management
- Revegetation
- Prescribed burning
- Drainage structures

Other activities addressed by some states include operations conducted in forested wetlands, wildfire control, slash management, specific sediment control measures, storage and disposal of hazardous substances or petroleum products, and livestock exclusion.

The presentation of information provided in the source documents differs in that some states provide detailed figures and tables for BMP design and implementation whereas other states focus more on the rationale for BMP use.

An overview of five types of state BMPs is presented in Appendix A. These five types of practices are generally considered among the more important for effectively controlling NPS pollution from forestry activities. Tables A-1 through A-5 provide an overview of the state practice components for revegetation, road surface drainage, skid trails, stream crossings, and streamside protection.

Revegetation practices are contained in 34 manuals or rules (Table A-1). Generally, practices address seed mixtures, including types, rates and dates of application, mulch and fertilizer. Timing of seeding and seedbed preparation is also included in a number of state practices.

In Table A-2, road surface drainage practices are described. To some degree, all 41 manuals summarized include practices for road surface drainage. A wide variety of designs for drainage structures are described including the use of wing ditches, broad-based dips, water bars, ditch relief culverts, turnouts, cross drainage culverts, and roadside ditches. Surface design components described focus primarily on crowning and out-sloping roads. Other practices described are directing discharges from drainage structures onto undisturbed forest floor or energy dissipators and away from streams. Restricting use of

roads during wet conditions is also incorporated into some manuals to lessen the impacts from road use and prevent accelerated failure of road drainage practices.

Some type of skid trail practice(s) is also generally incorporated into each of the state manuals summarized (Table A-3). Proper layout to avoid steep slopes and uphill skidding are often described, as are drainage structures such as waterbars and turnouts. Revegetation of skid trails is also frequently addressed. Other practices that are presented by some states are avoiding locating skid trails to concentrate runoff and not skidding in streamside management areas. Some states restrict ruts in skid trails to less than 6 inches.

Stream crossings are potentially one of the more serious sources of sediment to streams. Table A-4 describes some of the sizing requirements for culverts and bridges used by states and the use of inlet and outlet controls to protect these areas. The practice of installing stream crossings perpendicular to streamflow is included in many state manuals. Allowing for fish passage through stream crossings and the prompt removal of temporary stream crossings are also often described. In most manuals the use of fords is avoided unless specific site characteristics such as level, solid bottoms are present.

Protection of riparian areas is discussed in 29 of the state BMP manuals or regulations. These areas are commonly referred to as streamside management zones (SMZs), but they are also called riparian management zones or areas, filter strips, buffer strips, protective strips, and watercourse and lake protection zones. Some states have established a site sensitivity classification system that is used to determine the width of SMZs and the recommended forestry operations within SMZs. Other states use some minimum width and restrict logging within the streamside area.

Shading and avoiding temperature impacts are addressed by a number of states. The applicability of SMZ requirements including minimum widths and shading criteria, varies widely among the state manuals. Relatively few states apply these areas to intermittent streams.

Other practices used are preharvest planning and BMPs for pesticides and other chemicals. Preharvest planning is discussed by 18 states, 5 states of which require the development of a preharvest plan. In addition, three other states require a permit and/or submission of an erosion and sediment control plan. Seven state manuals deal exclusively with erosion and sedimentation control practices.

Twenty-two of the manuals contain BMPs for the use of pesticides and other chemicals. The manuals present information on pesticide characteristics and site factors affecting fate and transport and describe a range of practices including integrated pest management; transportation, storage, mixing, and application methods; and responding to spills.

While this overview provides an indication of some of the types of practices described in state BMP manuals, it also indicates the variability in specific practice components between state programs. This variability makes it extremely difficult to make general summary statements about the types of practices used by various states. The matrices in Appendix A illustrate the range of these practice components, as well as some of the similarities between state practices. The summaries contained in this document provide additional information related to these and other practices described in each state's BMP manual or rules. Appendix B provides information obtained from an NASF survey and lists state contacts and additional technology transfer information that is available or being developed.

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- Neary, D.G., W.T. Swank, and H. Riekerk. 1989. An Overview of Nonpoint Source Pollution in the Southern United States. In *Proceedings of the Symposium: Forested Wetlands of the Southern United States, July 12-14, 1988, Orlando, FL*. USDA Forest Service, General Technical Report SE-50, pp. 1-7.
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- USEPA. 1993. *Water Quality Effects and Nonpoint Source Control for Forestry: An Annotated Bibliography*. U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA 841/B-93-005.

ALABAMA

Reference: Alabama Forestry Commission.
1992. *Alabama's Best Management Practices for Forestry (Draft)*.

BEST MANAGEMENT PRACTICES

1. Streamside Management Zones
2. Stream Crossings
3. Forest Roads
4. Timber Harvesting
5. Reforestation/Stand Management
6. Wetlands
7. Revegetation/Restoration

1. Streamside Management Zones

The streamside management zone should be maintained on both sides of all perennial and intermittent streams and should extend at least 35 feet from a definable bank. Greater widths are recommended for highly erodible soils, steep banks, and wildlife habitat. The SMZs must be wide enough to maintain water quality standards.

Partial cut is the recommended harvesting method in SMZs along perennial streams. Fifty percent residual crown cover should be left. SMZs along intermittent streams can be harvested using partial cut or regeneration cut. There is no minimum residual crown cover requirement; only vegetative cover must remain. Do not harvest trees from banks, beds, or steep slopes if it will destabilize the soil. Any tops or other logging debris dropped into water must be removed. However, organic debris in the water prior to the harvest should not be removed from the stream.

Mechanical site preparation should not be used in SMZs. Reforestation should be achieved by natural regeneration, hand planting, or direct seeding.

Fertilizer should not be used in the SMZ. If a herbicide is used, it should be applied directly to the target pest and not broadcast-sprayed. Strict adherence to all label restrictions must be observed.

2. Stream Crossings

The crossing of streams by roads, skid trails, or firebreaks should be avoided. When streams must be crossed, locate the crossings where the bank will be least disturbed. Install crossings at right angles to straight sections of the channel. The banks should have gentle slopes, and the path through the SMZ should be straight. Water diversions should direct upland runoff onto the forest floor to filter out sediment and other pollutants. Provide for normal passage of water and aquatic animals within the channel.

Fords can be used where the streambed is firm, the banks are low, and the stream is shallow. Log crossings should not use green or small-diameter tops, limbs, and brush. Do not use fill dirt to improve the surface of log crossings.

Use adequately sized culverts to reduce road washouts and water impoundments. Stabilize fill materials using rip-rap, sand bags, concrete, mulch, hay bales, or silt fences. Routinely clean out culverts. Table 1 provides culvert diameters for various geographic regions within the state.

Bridges create the least disruption to stream flow and should be used on watersheds greater than 200 acres. Banks and fill material must be stabilized and protected from erosion. Spans must be installed to permit passage of

Table 1. Recommended Diameters for Culverts (inches)

Region	Drainage Area (acres)			
	10	50	100	200
Lower Coastal Plain	12	30	48	60
Upper Coastal Plain	12	18	30	42
Piedmont	12	30	42	54
Mountains	18	36	48	2(48)

all expected high flow. Remove all temporary crossings and stabilize the site. Permanent crossings must be stabilized and maintained.

3. Forest Roads

Carefully plan the location of all roads. Use existing roads only if they are acceptably located and drainage devices function properly. Avoid locating new roads in SMZs, on eroded gullies, or on troublesome or sensitive moisture-laden soils. The design standard should be at least the minimum for reasonable safety and consistent with anticipated traffic volume. Road slopes should be determined by topography and soil type.

During construction, minimize the amount of soil exposed. Balance cuts and fills whenever practical. Do not incorporate stumps, logs, or slash into the roadbed or fill material. Stabilize side banks as they are constructed. On flat roads, crown, out-slope, or in-slope the surface to minimize water retention. Install water diversion devices on roads with gradients, and direct discharge onto undisturbed forest floor or energy dissipators, such as rocks, mulch, or woody debris. Table 2 provides a spacing guide for diversion devices, but natural drainages and soil erodibility should also be considered when determining appropriate spacings.

Table 2. Spacing Distance between Diversion Devices

% Slope	Feet
3	233
5	180
10	140
15	127

Regularly inspect and maintain permanent roads. Road surfaces should be crowned, back-sloped, and water-barred as necessary to minimize erosion of the roadbed. Clean drainage devices as needed. Seed back slopes and roadbeds. Prohibit nonessential traffic on roads with high erosion potential during wet weather.

4. Timber Harvesting

Harvesting activities should be conducted in a manner that ensures long-term maintenance of water quality. Plan the location of temporary access roads, skid trails, and landings prior to construction. Avoid locating trails or landings on springs or in gullies. Logging roads and landings must be located on firm ground, outside SMZs, and above the high water mark of streams. Locate landings uphill of skid trails to provide the greatest dispersion of

water. If landings must be located downhill of skid trails, minimize erosion by using more smaller landings with fewer, smaller skid trails. Ground skidding should be conducted in a manner that does not disrupt natural drainage or create excessive soil displacement. Minimize skidding on steep gradients, but provide occasional breaks in grade when skidding on steep slopes can not be avoided.

Upon completion of the harvest, trash should be disposed of in accordance with applicable laws. Oils, fluids, and other toxic chemicals must never be drained into the soil. Landings and skid trails should be stabilized with vegetation and/or water diversion devices.

5. Reforestation/Stand Management

Mechanical site preparation should be conducted in a manner that minimizes erosion, soil compaction, stream sedimentation, and deposition of debris into water bodies. Limit mechanical site preparation to the amount needed to achieve a well-stocked stand of desirable trees. Mechanical site preparation should not be conducted in SMZs or on slopes exceeding 25 percent.

Drum chopping is a favorable method of mechanical site preparation for the protection of soil and water quality. Straight blade bulldozing is the least desirable method. Follow the contour when disking, bedding on slopes greater than 2 percent and constructing windrows. Avoid overraking the area.

Herbicide applications must follow manufacturer's label instructions, EPA guidelines, and state law. Herbicides should not be aerially or broadcast applied in SMZs. Pesticides should not be applied directly onto or allowed to drift or wash into water bodies. Do not mix chemicals or clean equipment and pesticide containers in or near streams and water bodies.

Design and manage prescribed fire to minimize adverse environmental effects. Avoid burning on slopes 25 percent or greater. Where needed, install appropriate water diversions along firelines. Vegetate firelines to reduce erosion.

6. Wetlands

Conversion of forested wetlands to non-forestry use by permanent major drainage and/or placement of fill material into wetlands, as well as immediate or gradual conversion of wetland vegetation to predominantly non-wetland species by permanently altering the surface or subsurface reach, flow, or circulation of wetland water is subject to Clean Water Act section 404 Army Corps of Engineers (COE) permit requirements. All other "normal" silvicultural activities in wetlands are exempt from these requirements.

Streamside management zones should be established and maintained around the perimeter of all major drainages and open water bodies.

Forest roads must be constructed and maintained in a manner that ensures that flow and circulation patterns and chemical and biological characteristics of streams and water bodies are not impaired. Minimize the number, width, and total length of all roads and skid trails. Stabilize all road fill during and after construction to prevent erosion. All temporary fills should be removed in their entirety and the area restored to its original elevation.

Do not harvest timber during periods of flowing water. When harvesting wet sites, use special harvesting systems to minimize water quality hazards and negative site impacts, such as rutting, puddling, and soil compaction. Concentrate skidder traffic on a few areas

rather than over the entire area. If harvesting during dry periods, normal guidelines apply.

Reforestation activities, including mechanical site preparation, must not impair the flow or circulation within the wetland or reduce the reach of waters of the United States without a COE permit. Herbicides bearing the "wetlands" warning on the label must not be applied directly to surface waters or to intertidal areas below the high water mark.

7. Revegetation/Restoration

During site and seedbed preparation, surfaces should be shaped to allow for drainage and smoothed to permit use of conventional equipment. Soil tests are recommended to determine whether agricultural limestone and fertilizer are needed to help establish vegetative cover. Lime and fertilizer should be incorporated into the top 2-4 inches of soil on slopes less than 6 percent, into the top 2 inches of soil on slopes between 6 and 10 percent, and onto the surface only for slopes greater than 10 percent. Immediately after seeding, mulch should be applied to retain seed, lime, and fertilizer and to maintain moisture and prevent extreme temperatures on the soil surface.

Actively eroding gully systems should be rehabilitated by redirecting or eliminating water flow through the area and then revegetating the area. Avoid operating in stabilized gully systems.

State Contact:

Don Burdette
Environmental Forester
Alabama Forestry Commission
(205) 240-9378

Other Available State Information

Manuals/ Books	<i>Alabama's Best Management Practices for Forestry (1989); Water Quality Management Guidelines and BMPs for Alabama's Wetlands</i>
Brochures	<i>Alabama's Best Management Practices for Forestry (1990)</i>

ALASKA

Reference: State of Alaska. 1992. *Draft Forest Resources and Practices Regulations*.

The following regulations and practices apply to any operation on state land, other public land, or private land if all of the following criteria are met:

- (1) the operation is on forest land as defined by AS 41.17.950;
- (2) the operation involves any of the following activities:
 - (a) harvesting, including felling, bucking, yarding, decking, hauling, log dumping, log transfer, log rafting;
 - (b) road construction or reconstruction, material source development, and maintenance of an existing road or bridge;
 - (c) site preparation;
 - (d) precommercial thinning;
 - (e) slash treatment; or
 - (f) any other activity leading to, or connected with, commercial timber harvest;
- (3) a commercial operation that intersects, encompasses, or borders on surface waters or a riparian area or that, for a single landowner or operator, equals or exceeds in the aggregate the following acreage:
 - (a) 10 acres in Region I;
 - (b) 40 acres in Region II;
 - (c) 40 acres in Region III for landowners who own more than 160 acres (if a landowner has 160 acres or less, then an operation on any of that 160 acres that is not a commercial forest operation).

BEST MANAGEMENT PRACTICES

1. Notification and Plan of Operation
2. Riparian Standards
3. Road Location, Construction, and Maintenance
4. Timber Harvesting
5. Reforestation and Site Preparation
6. Miscellaneous Provisions

1. Notification and Plan of Operation

Before beginning an operation on forest land, the operator must file a detailed plan of operations that must include the following information:

- (1) name, address, and approving signature of the forest landowner, timber owner, and operator;
- (2) a 1:63,360 scale USGS quadrangle map showing the proposed area of operation and suitable for duplication on 8½- by 11-inch paper;
- (3) four copies of a map at a scale providing the most detail available, showing the sites of the proposed activities, such as unit boundaries;
- (4) the expected dates to begin and complete operations;
- (5) the following surface waters information:
 - (a) the location and, if applicable, the classification of known surface waters that abut or are within the harvest units;
 - (b) the approximate location of proposed stream crossings;
 - (c) the approximate location of stream crossings requiring approval from the Department of Fish and Game; and
 - (d) the approximate location of surface waters for which the operator requests the Department of Fish and Game to

- determine or verify the presence of fish, as determined by a field inspection;
- (6) the boundaries of cutting units, harvest techniques (clearcut, etc.), and, where known, the yarding techniques and location of landings;
 - (7) the following road information:
 - (a) the approximate location of a mainline or spur road and whether the road is intended to be permanent or temporary;
 - (b) any road to be closed during the term of the plan of operation;
 - (c) any known road to be located in a riparian area for use as other than a water crossing;
 - (8) the approximate location of a material site;
 - (9) the following information for areas that are in cutting units or are traversed by roads:
 - (a) known unstable or slide-prone slopes;
 - (b) slopes greater than 67 percent; and
 - (c) site-specific measures designed to prevent slope instability due to road construction in areas identified under (9a) or (9b) of this paragraph;
 - (10) reforestation and site preparation methods;
 - (11) description and anticipated location of temporary housing, fuel storage sites, and associated wastewater and solid waste disposal facilities;
 - (12) location of log transfer and sort yard facilities;
 - (13) measures for control of insect infestation or disease outbreak (where applicable);
 - (14) requests for variation from riparian standards; and
 - (15) information regarding the location and estimated timing of the stream crossing activity when a short-term water quality variance for construction of a stream crossing is required.

An operator may provide the local office with a voluntary plan of operations describing long-term plans for timber harvesting.

2. Riparian Standards

Table 3 presents the riparian standards for various land categories as set forth in AS 41.17.116, AS 41.17.118, and AS 41.17.119. The following operations are allowed within the riparian area:

- road building when no feasible alternative exists;
- water body crossing;
- felling and removal of hazardous trees along roadways as required by state and federal law;
- locating material sites in braided, glacial floodplains;
- removal of a portion of a downed tree that lies greater than 25 feet from the streambank;
- installation of blocks, or similar devices, on a tree required for retention under this chapter if the device is installed to minimize damage to the tree;
- use of trees required for retention under this chapter for use as lift trees or tail holds;
- hanging of rigging through the riparian area consistent with operator safety requirements and to have a clear line of sight and working area for the rigging; and
- in the case of buffer strips for lands identified in AS 41.17.118 and .119 only, yarding corridors and other logging systems that do not cause a significant adverse impact to the riparian habitat.

Table 3. Riparian Standards

Land Type	Water Body Classification	Timber Harvesting Restrictions
Private land Region I	Type A	No harvesting within 66 ft of water body
	Type B	Operations within 100 ft of the stream or to the break of the slope, whichever area is smaller, must comply with slope stability standards
	Type C	Operations within 50 ft of the stream or to the break of the slope, whichever area is smaller, must comply with slope stability standards
Private land Regions II and III	An anadromous or high-value resident fish water body	Operations within 100 ft of water body must be sited and designed primarily to protect fish habitat and water quality
State land	An anadromous or high-value resident fish water body (North of Alaska Range)	No harvesting within 100 ft immediately adjacent to water body, unless the division determines that adequate protection remains for the fish habitat
	An anadromous or high-value resident fish water body (South of Alaska Range)	No harvesting within 100 ft immediately adjacent to water body Harvesting may occur between 100 and 300 feet from the water body, but must be consistent with the maintenance of important fish and wildlife habitat
Other public land	An anadromous or high-value resident fish water body (North of Alaska Range)	No harvesting within 100 ft immediately adjacent to water body
	An anadromous or high-value resident fish water body (South of Alaska Range)	No harvesting within 100 ft immediately adjacent to water body, unless the commissioner determines that adequate protection remains for fish habitat

3. Road Location, Construction, and Maintenance

Minimize the amount of road construction by using existing roads when feasible and by avoiding isolated patches of timber that would require additional road construction. Locate

roads to fit topography, and avoid locating roads on marshes, nonforested muskegs, recently abandoned stream channels, slopes greater than 67 percent, unstable slopes, slide-prone areas, and deep gullies where fine-textured soils such as clay or ash soils exist. Roads should be located outside the riparian

area except for waterbody crossings or where no feasible alternative exists. A stream crossing or a road in any riparian area must be designed and located to minimize significant adverse effects on fish habitat and water quality. Minimize the number of stream crossings, and cross streams at right angles.

When constructing forest roads, use end-hauling and full-bench construction techniques if mass wasting from overloading on an unstable slope or erosion of sidecast material is likely to occur and cause degradation of surface or standing water quality. Treat unstable soils with effective and appropriate erosion control measures, such as grass seeding, erosion control mats, or end-hauling materials. Construction on slopes greater than 67 percent, on an unstable slope, or in a slide-prone area require the following additional measures:

- do not bury significant amounts of organic debris and slash or log chunks more than 5 cubic feet in volume in the load-bearing portion of the road;
- balance cuts and fills to the greatest extent possible, but do not use excavated material as fill if it is unstable, fine textured, or prone to mass wasting; and
- do not conduct excavation or blasting activities under saturated soil conditions.

Spoil, waste, and overburden generated during road construction should be deposited on an upland site and stabilized by effective erosion control measures. Winter roads must be constructed to avoid degradation of water quality. The roadbed should be protected from rutting, ground disturbance, or thermal erosion. Avoid soil cuts or fills in thawed, unstable permafrost terrain.

Minimize erosion of roadbed, cut bank, and fill slopes through the use of cross drains, ditches, relief culverts, bridges, water bars, diversion ditches, or other such structures demonstrated to be effective. These drainage structures must be installed at natural drainages. The table provided for minimum spacing is specified by region and slope. Discharge from drainage structures should be directed away from unstable soils and onto vegetated areas.

A temporary bridge or culvert and the adjacent roadway must be constructed to withstand the 25-year flood. A permanent bridge or culvert and the adjacent roadway must be constructed to withstand the 50-year flood. Bridges must be installed to provide fish passage and minimize disturbance to the bed and banks of a stream. Protect bridge approaches from erosion by using planted or seeded ground cover, bulkheads, rock rip-rap, retaining walls, or other equally effective means. Special restrictions apply to bridge construction and repair on anadromous fish waters. Culverts smaller than 12 inches in diameter may not be installed. A culvert must discharge onto material that will not easily erode. With prior notification to the division, properly prepared and maintained fords may be used during a period of low flow. Fords should cross perpendicular to the stream flow, and the approaches must be properly ballasted or otherwise stabilized to avoid sedimentation.

On active roads, the surface must be maintained as necessary to minimize erosion of the surface and the subgrade, and all culverts, flumes, and ditches must be kept functional. As soon as feasible following the termination of active use, ditches and drainage structures must be maintained as necessary to ensure water flow and fish passage, and the road surface must be crowned, out-sloped, water barred, or otherwise left in a condition not conducive to erosion. Permanently closed

roads should have bridges, culverts, and fills removed. In areas accessible to highway vehicles, the road should be blocked so that four-wheel vehicles cannot pass the point of closure.

4. Timber Harvesting

Landing location, except when frozen, must avoid surface and standing waters and minimize use of marshes and nonforested muskegs. Landings must be located, constructed, and operated to prevent logs, vegetative debris, and sediment from entering surface and standing waters. Landing location should provide for a logging layout that will reduce the overall adverse effects of the operation. Minimize sidecast or fill, and construct landings no larger than necessary for safe operation of equipment. Where slopes are greater than 67 percent, unstable, or in a slide-prone area, fill material used in the construction of landings must be free of loose stumps and excessive accumulations of slash and must be mechanically compacted in layers where necessary to prevent soil erosion and mass wasting. Landings must be sloped, water barred, ditched, or otherwise constructed and maintained to minimize the accumulation of water on the landing.

Trees should be felled in a direction that minimizes damage to trees retained in partial cuts. Where feasible, trees must not be felled into riparian timber retention areas or surface waters. Equipment must not be operated in surface waters without prior notice to the division. If trees are felled into fish-bearing waters, limbs and other small debris must be removed within 48 hours. This provision may be waived if the Department of Fish and Game deems the material deposited in the water body will benefit fish resources. If trees are felled into non-fish-bearing surface or standing waters, the trees and debris must be removed

at the earliest feasible time to avoid degradation of water quality.

When cable yarding, logs must be fully suspended above or yarded away from surface waters. Cross stream yarding must be used when full suspension or split yarding would likely cause greater degradation of surface water quality or impact fish habitat. Cable yarding across surface waters must be conducted in a manner that avoids degrading water quality and minimizes damage to stream channels, stream banks, retained trees, understory vegetation, stumps, and root systems. The direction of log movement between stream banks must be as close to right angles to the stream as feasible. No timber may be yarded across anadromous or high-value resident fish waters without prior notice to the division. An operator should use maximum available deflection and uphill yarding techniques. Where downhill yarding is used, lift the leading end of the log by deflection and minimize downhill movement of slash and soils. Yarding across marshes and nonforested muskegs must be conducted in a manner that minimizes damage to vegetative cover.

Skidding of timber or operation of equipment in anadromous fish waters requires the written approval of the Department of Fish and Game. Operations in other surface waters, marshes, or nonforested muskegs requires prior notice to the division. Equipment may be operated on frozen surface waters, marshes, or nonforested muskegs without prior notice to the division. An operator may not use a tracked skidder, a wheeled skidder, or a logging shovel during saturated soil conditions. During winter logging, substantial concentrations of debris that enter surface waters or that may enter surface waters from winter trails must be removed before thaw. Locate skid trails to minimize degradation of surface water quality, and keep trails to

minimum feasible width. Out-slope trails where feasible, and use water bars or other appropriate techniques to prevent or minimize sedimentation. Skidding on slopes is restricted where degradation of surface or standing water is likely to occur. Within the riparian area the number of skidding routes must be limited; skidding must minimize damage to retained trees, stumps, root systems, understory vegetation, and soils; and one-end suspension of logs must be achieved.

Unstable slash concentrations around landings must be disposed of, or dispersed, to prevent entry into surface waters. Concentrations of slash may be reduced by scattering, piling, or windrowing, mechanized chipping, compacting, burying, controlled burning, or other method allowed by the division. Controlled burning requires approval from the Department of Environmental Conservation and may require a permit from the division. Burns must occur under weather conditions that minimize the chance of air quality degradation and fire escape. Riparian areas must be protected from fire during burns.

5. Reforestation and Site Preparation

Adequate reforestation must be achieved within 5 years after harvest in Region I and 7 years after harvest in Regions II and III. The reforestation plan must include the preferred target species, regeneration techniques, and site preparation methods. Minimum stocking standards are listed for the various regions. A forest landowner in Regions II and III who intends to rely on natural regeneration for reforestation must ensure a seed source of well-formed, vigorous trees of commercial tree species, and the seed source must be capable of distributing an adequate amount of seed throughout the harvest area to meet the reforestation requirements.

Site preparation must incorporate reasonable measures to protect residual trees, minimize degradation of surface water quality or harm to fish habitat, and minimize the use of heavy equipment where soil compaction or impacts to drainage will cause degradation of site productivity.

6. Miscellaneous Provisions

Petroleum products and waste material, such as crankcase oil, fuel, grease, filters, hydraulic fluid and their containers; machine parts; wire rope; oil-contaminated soils; scrap culverts; or similar scrap wastes resulting from operations must be disposed of in a manner that does not violate water quality standards.

ARKANSAS

Reference: Arkansas Forestry Commission.
Best Management Practices Guidelines for Silviculture.

BEST MANAGEMENT PRACTICES

1. Planning
2. Road Construction and Maintenance
3. Harvesting
4. Mechanical Site Preparation
5. Silvicultural Chemicals
6. Streamside Management Zones

1. Planning

Planning of harvest operations should maximize efficiency and economy of motion, preserve soil integrity, and protect water quality. Topographic maps, aerial photographs, and soil surveys should be used in combination with local knowledge or field reconnaissance to ascertain site conditions. Operations should be scheduled to avoid seasonal water problems and to minimize adverse impact on soils and water quality. Design the harvest setting boundaries to use natural drainage channels, topographic terrain, roads, and forest type changes. The size of the setting should be consistent with minimizing soil movement and protecting water quality. The setting layout should avoid narrow, unmanageable strips of timber susceptible to windthrow. Plan skidding design to avoid natural drainages and to balance skidding distances against road densities.

2. Road Construction and Maintenance

Locate roads along the contour, away from streams, and where topography permits, along the crest of long ridges. Avoid locating roads in narrow canyons, marshes, wet meadows, natural drainage channels, and streamside management zones. Use the minimum design standard necessary to support anticipated traffic volume with the least environmental impact. Minimize the number of stream crossings, and where necessary, plan the crossing perpendicular to the main channel.

During construction, plan and conduct work to minimize erosion. Right-of-way timber should be removed or decked outside borrow pits. Minimize the need for borrow pits by balancing cuts and fills to the greatest extent possible. Design cut-and-fill slopes to the normal angle of repose or less. Place sidecast or fill material above the ordinary high water mark of any stream, except where necessary at stabilized stream crossings. Seed and mulch areas with high erosion potential.

Design roads to drain naturally by crowning, ditches, culverts, and/or out-sloping. Use diversion or wing ditches to carry road drainage water away from the road and onto undisturbed forest floor. Install ditches, culverts, cross drains, and wing ditches at low points in the road gradient. Drainage structures should not discharge onto erodible material unless erosion protection measures are employed. Adequately size culverts to accommodate anticipated water flow.

Construct stream crossings to minimize disturbance to banks and existing channels and, during periods of low flow, to minimize the threat of erosion. Machine activity in the streambed should be avoided unless deemed absolutely necessary. Use a bridge or culvert if a ford would result in rutting or siltation. Bridges should not constrict clearly defined

stream channels. Permanent structures should be designed and constructed to accommodate the normal flood level. Protect low-water bridges, fills, and earth embankments from erosion by high water.

Maintain roads by crowning or out-sloping the road surface, revegetating or stabilizing exposed soil areas, and removing blockages or obstructions from culverts and ditches. Roads not currently in use should be periodically inspected to ensure their integrity.

3. Harvesting

Locate landings to minimize adverse impacts of skidding on the natural drainage pattern. The landings should be located on firm ground outside SMZs and should use the topography to provide natural drainage of the landing and disperse runoff onto the forest floor. Landings located on navigable waters for barge loading and transportation of logs must comply with Corps of Engineers regulations.

Locate skid trails to use the topography and maintain natural drainage patterns. Skid trails should not run parallel to a stream where the trail would be below the average high water mark of the stream. Stream channels should not be used as skid trails. Where stream crossings cannot be avoided, use temporary culverts, portable bridges, logs and natural fords with firm bottoms, stable banks, and fairly level approaches. Remove all temporary crossings upon completion of use. Skid trails on slopes should have occasional breaks in grade to facilitate dispersal of water.

Fell trees parallel to the skidding direction with butts toward the landing. When near streams, directionally fell trees away from the channel to minimize debris entering the watercourse. Provide shading, soil stabilization, and water filtering effects of

vegetation along streams by one or more of the following methods:

- leave trees, shrubs, grasses, rocks, and naturally felled timber wherever they afford shade over a stream or maintain the integrity of soil near such a stream;
- harvest mature timber from the SMZ in such a way that shading and filtering effects are not destroyed; and
- where it is difficult to leave adequate vegetation within the SMZ to afford stream protection, reestablish cover as soon as possible after harvesting is completed.

When cable yarding across a stream cannot be avoided, streamside vegetation should be left undisturbed to the maximum extent possible.

Remove logging debris accidentally deposited in waterways. Do not deposit debris from landings into drainages or streams. Mulch and seed erosion-prone areas to help reestablish permanent vegetation. Logging litter, such as oil cans, grease containers, crankcase oil filters, old tires, broken cable, paper, and other trash, must be kept out of streams and should be disposed of in a designated legal landfill.

4. Mechanical Site Preparation

Perform mechanical site preparation to minimize disturbance of areas near streams or other water bodies. Train equipment operators to minimize soil disturbance, compaction, and displacement. Minimize disturbance in SMZs. Locate windrows along the contour and out of SMZs, and minimize placement of soil in windrows. Do not disk on steep slopes or slopes with thin or highly erodible soils. Provide water outlets on bedded or furrowed areas at locations that will minimize movement

of soil. When ripping, follow the approximate contours.

5. Silvicultural Chemicals

Use chemicals in accordance with manufacturer's label instructions, EPA registration requirements, and all state and federal requirements for use, registration, and application.

Maintain equipment used for transportation, storage, mixing, or application to prevent leakage of chemicals. When chemicals are mixed with water, provide an air gap or reservoir between the water source and the mixing tank, and use uncontaminated pumps, hoses, and screens. Mix chemicals and clean tanks only where possible spills would not enter water bodies.

Carefully plan aerial and ground applications to avoid direct and indirect entry of chemicals into surface waters. Do not apply chemicals where stream contamination is likely to occur. Do not apply chemicals when the likelihood of aerial drift exists. For aerial applications, use a bucket or spray device capable of immediate shutoff. When performing ground applications to treat seedlings, incorporate pesticides into the soil and not on the ground surface. In areas adjacent to open water, use injection or stump treatment herbicide methods.

Clean equipment and containers where contamination of water bodies is not likely to occur. Rinse containers and mixing apparatus at least three times and spray the rinse water over the application area. Label, remove, and dispose of containers in accordance with applicable local, state, and federal laws. Maintain a record of application in accordance with state and federal laws and retain it for at least 2 years. If any hazardous chemical is accidentally spilled, contain and neutralize the

chemical and notify the Department of Pollution Control and Ecology.

6. Streamside Management Zones

SMZs must be wide enough to protect water quality and stream characteristics. Design SMZs on a case-by-case basis considering soil type, slope, vegetative cover, flow, and stream classification. Restrict activities that would cause pollution or erosion. Locate roads, skid trails, and landings outside SMZs. Harvest mature timber in a manner that will not destroy the filtering effects of the zone.

State Contact:

Randall L. Leister
Arkansas Forestry Commission
(501) 664-2531 ext. 34

Other Available State Information

Manuals/ Books	<i>A Guide to Better Forestry Practices and Water Quality;</i> <i>A Guide to Better Logging and Better Water Quality</i>
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CALIFORNIA

References: California Department of Forestry and Fire Protection. 1991. *California Forest Practice Rules, Subchapter 4: Coast Forest District Rules*; and the Z'berg-Nejedly Forest Practice Act of 1973

The Z'berg-Nejedly Forest Practice Act of 1973 states that no person may conduct timber operations unless a timber harvesting plan prepared by a registered professional forester has been submitted to the department. The 1991 California Forest Practice Rules, Subchapter 4: Coast Forest District Rules, require that all harvest plans be approved by the Director of Forestry prior to the commencement of harvesting operations. The plan must be applicable to a specific piece of property or properties and must be based on such characteristics of the property as vegetation type, soil stability, topography, geology, climate, and stream characteristics. The Z'berg-Nejedly Forest Practice Act stipulates that the plan must include, at a minimum, all of the following information:

- (1) the name and address of the timber owner;
- (2) the name and address of the timber operator;
- (3) a description of the land on which the work is proposed, including a USGS quadrangle map or equivalent indicating the location of all streams, the location of all proposed and existing logging truck roads, and the boundaries of all Site I classification timberlands to be stocked;
- (4) a description of the silvicultural methods to be applied, including the type of logging equipment to be used;
- (5) an outline of the methods to be used to avoid accelerated erosion from timber operations to be conducted within proximity of a stream;

- (6) special provisions, if any, to protect any unique area within the area of the timber operation;
- (7) the expected dates of commencement and completion of timber operations;
- (8) a certification by the registered professional forester preparing the plan that he/she or a designee has personally inspected the plan area; and
- (9) any other information the board provides by regulation to meet its rules and standards of this chapter.

The 1991 California Forest Practice Rules require an extensive amount of additional information to be included in the plan.

BEST MANAGEMENT PRACTICES

1. Harvesting Practices and Erosion Control
2. Site Preparation
3. Watercourse and Lake Protection
4. Logging Roads and Landings
5. Coastal Commission Special Treatment Areas
6. Prescribed Burning
7. Cumulative Impacts Assessment

1. Harvesting Practices and Erosion Control

All plans must show the estimated erosion hazard rating of the plan area. Erosion control structures must be installed on all constructed skid trails and tractor roads prior to the end of the day if the U.S. Weather Service forecast is a "chance" (30 percent or more) of rain before the next day, and prior to weekend or other shutdown periods. Water breaks must be constructed for tractor roads, roads, layouts, and landings that do not have permanent and

adequate drainage facilities or structures. The maximum distance between water breaks is specified according to slope and estimated erosion hazard rating. Discharges should flow onto vegetative cover, duff, slash, rocks, or less erodible material. Water breaks and other erosion controls must be maintained during timber operations and for a period extending as much as 3 years after work completion.

Trees must be felled to lead in a direction away from watercourses and lakes. Slash and debris from timber harvesting operations may not be placed in locations where they could be discharged into a Class I or Class II watercourse or a lake.

Tractors or other heavy equipment must not be operated in unstable areas; on any slopes greater than 65 percent; on slopes greater than 50 percent that lead without flattening to a Class I or Class II watercourse or a lake; or in areas having average slopes over 50 percent, where the erosion hazard rating is high. Machinery equipped with a blade may not operate on skid roads or slopes that are so steep as to require the use of the blade for braking. Tractor yarding or the use of tractors for constructing layouts, firebreaks, or roads may be done only during dry periods where soils are not saturated.

Cable yarding must be conducted in such a manner that the installation and use of cable lines will not incur unreasonable damage to the residual trees. Tractors must not be used in areas designated for cable yarding except to pull trees away from streams, to yard logs in areas where deflection is low, or where swing yarding is advantageous.

Equipment used in timber operations must not be serviced in locations that will allow grease, oil, or fuel to pass into lakes or watercourses.

2. Site Preparation

When site preparation will occur on the logging area, a site preparation addendum will be incorporated into the harvest plan. Heavy equipment must not be used for site preparation under saturated soil conditions. Undisturbed areas or energy dissipators must be used to control and disperse concentrated runoff from roads, landings, tractor roads, firebreaks, and erosion control facilities where it flows into the site preparation areas.

3. Watercourse and Lake Protection

All lakes or watercourses that contain or conduct Class I, II, III, or IV waters must be designated on the harvest plan map and the width of the watercourse and lake protection zone (WLPZ) determined by slope and water class. Heavy equipment must not be used in timber falling, yarding, site preparation, or hauling operations within the WLPZ. The amount of vegetation removal within the WLPZ is determined by a registered professional forester during an on-site inspection. Soil stabilization measures may include, but are not limited to, mulching, rip-rapping, grass seeding, or the use of chemical soil stabilizers. The timber operator must not discharge soil, silt, bark, slash, sawdust, petroleum, or other organic or earthen material from any logging, construction, or associated activity into any stream or lake in quantities deleterious to fish, wildlife, or other beneficial uses of water.

4. Logging Roads and Landings

Roads and landings must be planned so that an adequate number of drainage facilities and structures are installed to minimize erosion on roadbeds, landing surfaces, sidecast, and fills. Road and landing sites will be planned to

minimize disturbance to logging area. The following factors are to be considered:

- use existing roads whenever feasible;
- use systematic road layout patterns to minimize total mileage;
- avoid routes near watercourses, marshes, wet meadows, or unstable areas;
- minimize number of water crossings;
- locate roads on natural benches, flatter slopes, and areas of stable soils;
- plan to fit the topography; and
- use logging systems that will reduce excavation or placement of fills on unstable areas.

No road or landing construction may occur under saturated soil conditions. Landings must be the minimum in width, size, and number consistent with the yarding and loading system to be used, and must be no greater than one-half acre. Waste organic material must not be buried in the landing fill. Road construction activities in the WLPZ are prohibited, except for stream crossings. Watercourse crossing drainage structures on logging roads must be planned, constructed, and maintained or removed according to the following standards:

- the number of crossings must be kept to a feasible minimum;
- the location of all new permanent and temporary structures must be shown on the harvest plan map, and the minimum diameter of permanent culverts must be specified;

- the location of structures on watercourses that support fish must allow for unrestricted passage of fish;
- fills must be excavated to form a channel that is as close as feasible to the natural watercourse grade and orientation and is wider than the natural channel; and
- excavated material and any resulting cut bank must be sloped back from the channel and stabilized to prevent slumping and to minimize soil erosion.

Install drainage structures so as to minimize erosion, to ensure proper functioning, and to maintain or restore the natural drainage. Drainage structures must be of sufficient size, number, and location to carry runoff water off of roadbeds, landings, and fill slopes. Do not direct discharge from drainage structures onto erodible material unless energy dissipators are used. Specifications for water break spacing, installation, and maintenance are provided in the practice rules.

Roads and landings must be maintained in a manner that minimizes concentration of runoff, soil erosion, and slope instability. Abandonment of roads, watercourse crossings, and landings must be planned and conducted in a manner that provides for permanent maintenance-free drainage to soil resources; minimizes concentration of runoff, soil erosion, and slope instability; prevents unnecessary damage to soil resources; promotes regeneration; and protects the quality and beneficial uses of water.

5. Coastal Commission Special Treatment Areas

The Coastal Commission Special Treatment Area is defined as an identifiable and geographically bounded forest area designated within the Coastal Zone that constitutes a

significant wildlife and/or plant habitat area, area of special scenic significance, and any land where timber operations could adversely affect public recreation areas or the biological productivity of any wetland, estuary, or stream especially valuable because of its role in a coastal ecosystem. Regulations provide for larger watercourse protection zones and higher stocking standards and limit reentry for 10 years.

6. Prescribed Burning

All slash created by road construction or timber operations within the fire protection zone must be treated by piling and burning, chipping, removal from the zone, or burying. This treatment must be completed by June 1 of the year following creation of the slash. Slash piles and concentrations must be sufficiently free of earth and other noncombustible material for effective burning. Concentrations of slash outside the fire protection zone may be isolated and burned after the first wet fall or winter weather, and burning should be completed by April 1 of the following year. The use of broadcast burning is restricted in some districts. Use of broadcast burning prescription in the WLPZ for Class I and Class II waters is prohibited. Broadcast burning must not fully consume the larger organic debris, which retains soil on slopes and stabilizes watercourse banks.

7. Cumulative Impacts Assessment

Regulations provide for assessing cumulative impacts of past, present, and foreseeable probable future projects on the watershed, soil productivity, and biological (wildlife) resources. All significant impacts must be mitigated.

State Contact:

Ross Johnson
Dept. of Forestry
(916) 653-4995

or

Pete Cafferata
Dept. of Forestry
(916) 653-9455

Other Available State Information

Manuals/ Books	<i>California Forest Practice Rules</i> - updated annually
Brochures	An extensive selection of publications that address various forestry issues and regulations are available from the California Department of Forestry and Fire Protection at (916) 653-7211

CONNECTICUT

Reference: Connecticut Resource Conservation and Development Forestry Committee. 1990. *Timber Harvesting and Water Quality in Connecticut: A Practical Guide for Protecting Water Quality While Harvesting Forest Products.*

BEST MANAGEMENT PRACTICES

1. Site Planning Considerations
2. Truck Roads, Skid Roads/Trails and Landings
3. Drainage Structures
4. Sediment Control Measures
5. Post-Harvesting Considerations

1. Site Planning Considerations

Prepare a plan prior to the start of each harvesting operation. Plan the location using topographic maps, aerial photos, USDA soil survey maps, and property maps. Avoid steep slopes, springs, wetlands, poor drainage areas, rock outcrops, and other obstacles. Plan landings and roads so that they can be used in subsequent harvests. Roads should generally not exceed a 10 percent slope, except for short sections to avoid obstacles, and if possible should be located on the high side of steep or wet areas. Minimize the number of stream crossings and, if possible, locate the crossings in flat areas. If the value of the timber in a section of the harvest site would be less than the cost of environmentally safe harvesting, the section should not be harvested.

2. Truck Roads, Skid Roads/Trails and Landings

Road drainage is extremely important in minimizing erosion and sedimentation. To minimize water accumulation on the road surface, the road may be in-sloped, out-sloped, or crowned. Divert water off the road surface with the use of ditch-relief culverts and/or broad-based dips. Broad-based dips should be used only on roads with gradients of 10 percent or less.

When constructing truck roads, use bridges or culverts to cross streams. Construct stream crossings where the erosion hazard can be minimized. The stream channel should be straight, and the banks should have a gentle gradient. Fords may be used only where the stream bottom is ledge, stone, gravel, or sand.

Use a diversion or interceptor ditch above landings to minimize the amount of up-slope water reaching the landing areas. Properly dispose of all oil cans, old lubricants and filters, crankcase drainings, and other potential pollutants. Do not use streambeds as skid trails.

3. Drainage Structures

Drainage structures should be used to divert runoff from roads, skid trails, and landings. The choice of culvert type depends on conditions and the planned use of the road. Pipe culverts are recommended for permanent roads because of their long life and effectiveness. They should be used where adequate fill can be placed over the culvert, and open-top culverts should be used when adequate fill or machinery is not available to properly install pipe culverts. Locate drainage structures according to road grade as specified in Table 4.

Table 4. Spacing Guide for Drainage Structures (feet)

Road Grade (%)	Waterbars	Pipe Culverts	Dips, Turn-ups
1	400	450	450
2	250	300	300
5	135	200	200
10	80	140	140
15	60	130	130
20	45	120	120
25	40	65	
30	35	60	
40	30	50	

The discharge area should be protected with stone, grass sod, logs, or tree tops. Natural litter may be adequate if the terrain is not too steep.

4. Sediment Control Measures

Use baled hay or silt fence/filter fabric as sedimentation barriers. Filter strips should be used between watercourses and heavily disturbed areas, such as roads and landings. Minimize soil disturbance in filter strips. Table 5 contains recommended widths of filter strips, but good judgment and the details of the site should be used for a final decision.

Table 5. Recommended Filter Strip Widths

Land Slope (percent)	Width of Filter Strip (feet)
0	25
10	45
20	65
30	85
40	105
50	125
60	145
70	165

5. Post-Harvesting Considerations

Abandoned skid trails, roads, and landings should be stabilized upon completion of harvesting operations, and access should be restricted. Culverts, bridges, or other temporary structures placed in water courses should be removed. Grade major skid trails. Logging debris and trash should be removed from the landing, and the landing surface should be graded so that water does not flow onto the access road. Seed landings, approaches to stream crossings, and steep skid trail sections.

DELAWARE

Reference: Delaware Forestry Association.
Forestry Best Management Practices for Delaware.

The BMPs presented in this manual are advocated by the Forestry Section of the Department of Agriculture but have not been officially adopted by the Department of Natural Resources and Environmental Control.

BEST MANAGEMENT PRACTICES

1. Pre-Harvest Planning
2. Truck Haul Roads
3. Skid Trails
4. Log Decks, Landings, and Portable Sawmill Locations
5. Streamside Management Zone
6. Broad-Based Dip
7. Rolling Dip
8. Water Bars
9. Cross Road Drainage by Pipe or Open-Top Box Culvert
10. Stream Crossings
11. Water Turnouts
12. Site Preparation and Management
13. Revegetation of Bare Soil Areas
14. Wildfire Control and Reclamation

Forested Wetlands

15. Salvage and Sanitation in Streamside Management Zones
16. Forested Wetlands Preharvest Planning
17. Forested Wetlands Truck Haul Roads
18. Forested Wetlands Skid Trails
19. Forested Wetlands Log Decks

1. Preharvest Planning

A written preharvest plan should be prepared. The plan should include any or all of the following: property boundaries, streams and drainages, soil restrictions, slope and environmental concerns, approximate location of main haul road and skid trails, location of potential log landings, portable sawmill locations, stream or drainage crossings, and streamside management zones. A timber sale contract and the timing of harvest should also be included in the plan.

2. Truck Haul Roads

Roads should follow the contour as much as possible, with grades between 2 and 10 percent. On soils with a severe erosion hazard, grades should be 8 percent or less, but grades exceeding 12 percent for 150 feet may be acceptable provided measures are taken to prevent erosion. Vertical road bank cuts should not exceed 5 feet in height.

Roads (with the exception of stream crossings) should be constructed at least 50 feet from any flowing or identifiable streams. Intermittent or perennial streams should be crossed using bridges, culverts, or rock fords oriented as close to the right angle to the stream as possible. Fords may be used when stream banks are stable and stream bottoms are hard. Fords should be used only when vehicles crossing the stream do not cause increased sedimentation. Install water turnouts prior to a stream crossing to direct runoff water into undisturbed areas of the streamside management zone.

Out-slope the road surface where the road gradient and soil type will permit. In-slope the road toward the bank as a safety precaution on sharp turns, on road gradients of 15 percent or greater, or on clay or slippery roads. Use cross drainage on in-sloped or crowned roads

to limit the travel distance of runoff water.

On in-sloped or crowned roads, install broad-based or rolling dips within the first 25 feet of an upgrade if gradients begin to exceed 2 percent for more than 200 feet. Place roads on side slopes to avoid level ridgetops. Avoid wet floodplain soils.

Ensure good road drainage with properly constructed and spaced turnouts, broad-based dips, rolling dips, culverts, and bridges. Turnouts must be constructed to prevent water from cutting channels across the SMZ. Cut trees along the side of the road where sunlight is necessary to ensure drying of the road. Use brush barriers or check dams as needed along the road fill areas or other sensitive areas.

3. Skid Trails

Gradients should not be steeper than 15 percent. However, steeper segments may be required to avoid boundary lines or sensitive areas. Skid trails must be located outside the SMZ. Any skid trail that must cross a perennial or intermittent stream, or a drainage ditch that leads to a natural drainage, should use a bridge or culvert of acceptable design. Logs should not be skidded through intermittent or perennial streams. Approaches to water crossings should be as near to right angles to the stream direction as possible. Ruts should not exceed a depth of 6 inches, on average, over a distance of 50 feet, on slopes 5 percent or greater. Upon completion of skidding, the areas subject to erosion should have water bars installed immediately. Waterbars should be installed at a 30 to 45 degree angle downslope.

4. Log Decks, Landings, and Portable Sawmill Locations

Locate sites for decks and portable sawmills in advance of road construction and at least 50 feet from the SMZ. Decks and yards should

be on well-drained soils, and adequate drainage on approach roads and trails should be provided to prevent accumulation of runoff on the deck area. Oil and other wastes from servicing equipment should be drained into containers and disposed of in accordance with proper solid waste disposal practices. Garbage and trash must be removed and disposed of properly. Decks, landings, and portable mill locations should be stabilized to prevent erosion and sediment loss within the first 15 days of the next seeding season following completion of harvesting operations.

5. Streamside Management Zone

The minimum SMZ width on either side of a perennial stream should be 50 feet. SMZs may be desirable on intermittent streams for large drainage areas where wildlife or water quality is a major concern. Partial harvesting is acceptable with a minimum of 60 percent of the crown cover or 60 square feet of basal area per acre evenly retained. Limit the use of logging equipment in the SMZ to prevent the disturbance of the forest floor. Locate sawmill sites and decks outside the SMZ, and keep access roads to a minimum. Fertilizers should not be used in the SMZ.

6. Broad-Based Dip

Broad-based dips can be used on truck roads and heavily used skid trails having gradients of 12 percent or less. They should not be used for cross draining spring seeps, intermittent streams, or perennial streams. This practice may be substituted for other surface water cross drainage practices such as a pipe or box culvert. Specifications for spacing and installation are provided in the manual.

7. Rolling Dip

Rolling dips have the same applicability as broad-based dips, except they can be used on gradients of 15 percent or less. Specifications for spacing and installation are provided in the manual.

8. Water Bars

Water bars can be used on roads and skid trails where there will be no vehicular traffic. Proper spacing is determined by the percent grade of the road or skid trail. Water bars should be oriented at an angle of 30 to 45 degrees downslope to divert surface water off the road/skid trail.

9. Cross Drainage by Pipe or Open-Top Box Culvert

Culverts can be used for any size operation where cross drainage of storm water is needed for truck roads or major skid trails. Periodic maintenance is necessary to remove sediments, gravel, and logging debris and to allow normal flow of runoff water through the structure at all times. Specifications for spacing and installation are provided in the manual.

10. Stream Crossings

Culverts, bridges, or rock fords may be used to allow logging equipment to cross intermittent or perennial streams. Pipe culverts should be long enough so that both ends extend at least 1 foot beyond the edge of the fill material and should be placed on a 2 to 5 percent grade to prevent clogging. Erosion protection measures should be installed at the culvert outlet. Bridges should be constructed with minimum disturbance to the stream bank, channel, or adjacent SMZ. Rock fords or log fords may be used if no practical alternative exists. Approaches and stream bottoms must

be hard enough to ensure that no muddy water results.

11. Water Turnouts

Water turnouts can be used on any road or trail section where water would accumulate. The water should be diverted into undisturbed areas and should not feed directly into adjacent drainages or channels.

12. Site Preparation and Management

A forest management plan should be developed prior to any site preparation activities. No site preparation activities may be conducted in the SMZs. Prescribed burning and mechanical site preparation should be conducted in a manner least likely to cause erosion. Firelines should have cross drainage to disperse runoff. Windrows can be used during mechanical site preparation to trap sediment. Bedding can be used to overcome poor drainage, which can occur on flat sites with a high water table. Machine planting of seedlings should be done on the contour. On steep slopes, seedlings should be planted by hand.

All pesticides should be applied by certified personnel and in accordance with label instructions. Measures should be taken to prevent the pesticides from entering watercourses by direct application or surface runoff. Dispose of or clean all containers and application equipment according to label requirements.

Application of fertilizer mixtures should be at rates appropriate for tree species and soils. Fertilizer should not be broadcast within an SMZ.

13. Revegetation of Bare Soil Areas

After construction or close of harvesting, all disturbed areas (bare soil areas) with a grade

of 5 percent or greater or areas subject to erosion should be seeded to establish grass and/or legume vegetation within the first 15 days of the next seeding season. A long-term perennial, fine-rooted seed mixture should be used for effective erosion control. When seeding is done on highly erodible soils, or under adverse soil or weather conditions, mulch should be applied immediately after seeding. Seeded areas should be protected from grazing and unrestricted vehicle use.

14. Wildfire Control and Reclamation

Do not plow firelines directly into streams. After the fire, actively eroding gullies should be stabilized and bare soils revegetated. Stabilize and revegetate firelines and access roads.

Forested Wetlands

15. Salvage and Sanitation in SMZs

All previous rules for SMZs apply; however, small spots of damage (less than 1 acre) may be completely harvested.

16. Forested Wetlands Preharvest Planning

In addition to the specifications for normal preharvest planning, the wetlands preharvest plan should also consider the use of machinery with flotation devices to minimize impacts to the soil surface, identification of potential problems or events that may interrupt logging operations, and the scheduling of operations during extreme dry periods or during periods that enhance regeneration.

17. Forested Wetlands Truck Haul Roads

Use planking or wooden mats to improve the soil's ability to support traffic of heavy loads. Use oversized or balloon tires to reduce compaction and rutting. Construct fill roads

only when absolutely necessary. Gravel or crushed rocks should be used as fill to provide movement of ground water and serve as a base for the roadbed. Move equipment upland during periods of potential flooding and wet periods. Access to the area should be limited.

18. Forested Wetlands Skid Trails

The specifications are the same as for upland skid trails; however, sandy sloughs can be used as skid trails during the dry season (never when there is surface water present). Use wide tracks (24 inches or more) on bulldozers and flotation tires on skidders.

19. Forested Wetlands Log Decks

Whenever possible, locate log decks on the uplands or at higher elevations. All other guidelines are the same as the guidelines for upland log decks.

State Contact:

Nancy Milliken
Forestry Section
(302) 739-4811

Other Available State Information

Videos	Two 15 minute videos entitled <i>BMPs for Loggers and Pre-harvest Planning for Landowners</i>
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FLORIDA

Reference: Florida Department of Agriculture and Consumer Services, Division of Forestry. 1991. *Silvicultural Best Management Practices Manual*.

Florida has developed a site sensitivity classification system to be used in determining management activities on harvesting sites. Table 6 illustrates how site classification is determined by slope, soil erodibility, and the K factor.

BEST MANAGEMENT PRACTICES

1. Streamside Management Zone
2. Access Road Drainage
3. Access Planning and Considerations
4. Timber Harvesting Sites
5. Site Preparation and Planting
6. Prescribed Fire
7. Pesticides
8. Site Fertilization

1. Streamside Management Zones

A streamside management zone should be provided along all perennial streams, intermittent streams, and lakes 10 acres or

larger. Primary SMZs are 35 feet wide, and secondary SMZs vary from 0 to 140 feet, depending on the site sensitivity class. Mechanical site preparation, fertilization, and aerial application or mist blowing of herbicides and insecticides should be avoided within SMZs. Landings, log bunching points, and access roads (except at stream crossings) should not be located in SMZs. Plowed firelines should only be constructed in SMZs during emergency conditions.

In the primary SMZ, timber harvesting should be selective and should leave a volume equal to or exceeding one-half the volume of a fully stocked stand. Clearcutting is allowed in the secondary SMZ, but the degree or percentage of bare ground exposure should be limited, and that limit is dependent on the site sensitivity classification. Direct seeding, hand planting or machine planting on the contour, and basal application of pesticides are recommended practices within secondary SMZs. Prescribed burning may not occur in secondary SMZs on slopes greater than 18 percent.

2. Access Road Drainage

Culverts, cross ditches, and turnouts can be used to divert water from road surfaces to adjacent vegetated areas for dispersion. Broad-based dips are recommended for use on permanent access roads, especially heavily

Table 6. Site Sensitivity Classification

Soil Erodibility	K Factor	Slope (percent)					
		0-2	3-7	8-12	13-17	18-22	22+
Low	Less than 0.20	A1	A2	A3	A4	A5	A6
Moderate	0.21 thru 0.27	B1	B2	B3	B4	B5	B6
High	Greater than 0.28	C1	C2	C3	C4	C5	C6

traveled roads. Water bars are recommended for use on temporary access roads, firelines, and skid trails. Table 7 contains recommended maximum spacing of drainage structures based on site sensitivity classification.

3. Access Planning and Considerations

Prior to construction, carefully plan location using soil survey maps, topographic maps, and aerial photographs. Minimize stream and wetland crossings. Cross streams at right angles and place temporary or permanent aggregate on the road surface at stream approaches. Use temporary bridges and adequately sized culverts. Do not impede flow with hard surface crossings or improved fords.

Construct roads during dry periods, and balance cuts and fills. Drain roads using culverts, cross ditches, turnouts, etc., and outlet drainage devices into vegetated areas of adequate size to assimilate sediment loads. Minimize road width, and seed and fertilize unstable banks.

Maintain drainage measures and keep ditches and culverts free of obstructions. Close or restrict traffic on temporary and sensitive permanent roads to encourage stability.

4. Timber Harvesting Sites

Locate skid trails along the contour. Concentrate skid trails on organic soils and disperse them on mineral soils. Stabilize abandoned skid trails by installing water bars at recommended intervals. On erodible or steep slopes, seed and fertilize water bars. Remove all logging debris from watercourses, and remove all trash and garbage from harvested areas. Properly dispose of spent oil or other toxic liquids.

5. Site Preparation and Planting

Use site preparation techniques that are adequate to establish seedlings and minimize vegetative competition, but that are not needlessly disruptive of topsoil. Pull the chopper perpendicular to watercourses to orient indentations parallel to watercourse when chopping is not followed by bedding. Arrange beds parallel to watercourses. Keep the blade used to shear, push, or pile debris above the soil surface. Pull mechanical planters parallel to watercourses.

Table 7. Maximum Spacing of Drainage Structures (feet)

Drainage Method	Site Sensitivity Class (A-C)					
	1	2	3	4	5	6
Culverts and Cross Ditches	None	200	150	125	100	75
Water Turnouts	150 *	120	100	75	50	40
Broad-Based Dips	None	180	140	125	120	110
Water Bars	250	135	80	60	45	30

* The maximum spacing for class A1 is 200 feet

6. Prescribed Fire

Use water bars to stabilize firelines in Secondary SMZs. Orient firelines along the contour. Do not use prescribed fire in SMZs with slopes greater than 18 percent.

7. Pesticides

Use equipment that best directs the chemical to the target. Do not use aerial application and mist blowing techniques within SMZs. Do not leave pesticide containers on the site, and do not rinse spray equipment in watercourses.

8. Site Fertilization

Develop a prescriptive plan based on a soil or foliar analysis to indicate appropriate fertilizer type, application rate, and placement procedure. Avoid fertilizing in SMZs. Apply fertilizer in early spring to maximize nutrient uptake.

State Contact:

Jeff Vowell or
Tom Gilpin
Florida Division of Forestry
(904) 488-4090

Other Available State Information

Manuals/ Books	<i>Management Guidelines for Forested Wetlands in Florida (1988)</i>
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GEORGIA

Reference: Georgia Forestry Commission. 1988. *Recommended Best Management Practices for Forestry in Georgia*.

BEST MANAGEMENT PRACTICES

1. Streamside Management Zones
2. Stream Crossings
3. Access Roads and Their Construction
4. Timber Harvesting
5. Site Preparation
6. Reforestation
7. Forest Protection (Prescribed Burning and Firelines)
8. Chemical Treatment (Pesticides)

1. Streamside Management Zones

The streamside management zone consists of a primary zone and a secondary zone to be established along perennial and intermittent streams, lakes, and ponds. Table 8 provides the required widths for primary and secondary SMZs delineated by region.

Primary SMZ

Construction of roads or trails in the SMZ should be avoided. Any type of timber cutting practice, including clearcutting, is allowable

except along designated mountain trout streams. However, the use of wheeled or tracked vehicles should be avoided, and the timber should be cabled out of the SMZ. Felled trees and tops should be removed from the watercourse. Fire is prohibited in the primary SMZ. Mechanical site preparation or machine planting should be avoided, and revegetation should be performed by hand planting or direct seeding. Portable sawmills and log decks should be located outside primary SMZs. Aerial application of any pesticide should be avoided.

Secondary SMZ

The recommendations for the secondary SMZ are similar to those for the primary SMZ, but less restrictive. The careful use of wheeled or tracked vehicles is allowable, as is any type of planting that does not remove forest floor or expose mineral soil. Fire is also acceptable. Gully leveling should be avoided, unless immediately seeded and mulched.

2. Stream Crossings

Advance planning of road location should be used to reduce or eliminate the number of stream crossings. Bridges should be used over large streams (200+ acre watersheds), and properly sized culverts should be used in small streams (usually 200 acre or less watersheds). A table is provided in the manual for proper culvert sizing. Use temporary fords only where stream banks and bottoms are hard and

Table 8. Streamside Management Zone Widths Based on Regional Differences (feet)

Region	Primary SMZ	Secondary SMZ
Lower Coastal Plain	20	0
Upper Coastal Plain	40	40 *
Piedmont and Mountain	80	80

* Does not apply to bottomlands in this region

relatively level. Any structure or practice that would impede the free flow of water should be avoided. All approaches to stream crossings should be made at right angles and at gentle grades (about 3 percent). Soil around all culverts and bridges should be stabilized with seed and mulch.

3. Access Roads and Their Construction

The location of roads should be planned in advance to minimize the number of roads and their slopes. Roads should follow the contour as much as possible and should be located away from wet areas, SMZs, and the tops of ridges. Any roads located within the SMZ should have all exposed soil stabilized with seed and mulch. Road grades should be kept to 5 percent or less, except where terrain requires short steep grades. Avoid constant use of soft roads during wet conditions, and remove trees along roadsides to aid in drying out roads. Broad-based dips and water turnouts should be used at proper intervals to channel water from the road. Figures and specifications are provided in the manual. Temporary access roads should be retired upon the completion of harvesting. This includes reshaping, mulching, seeding, and installing waterbars.

4. Timber Harvesting

Log decks should be located on stable, well-drained areas and away from streams and ponds. Portable sawmills should be located at least 300 feet from any stream or water body, and the sawdust and mill waste should not be discharged in waterways. Minimize soil disturbance and exposure by alternating between several different skid trails instead of using only one primary skid trail. Skidding on steep slopes should be done on a gradual grade rather than straight up the slope. Leave logging debris on exposed soil, on dry washes, and at points of concentrated drainage from

skid trails and roads. Provisions should be made at lunch sites and sawmill setups for the disposal of garbage and human waste.

5. Site Preparation

Site preparation should be planned to consider water quality, with special emphasis placed on activities conducted in the SMZs. Soil disturbance should be kept to a minimum. Avoid all heavy site preparation on slopes greater than 20 percent. On highly erodible soils, use only drum chopping, herbicides, or prescribed burning. Windrows and planting beds should be constructed along the contour. On slopes, leave a natural buffer strip (10+ feet) between roads or roadside ditches and the prepared site. Do not pile debris in live or wet-weather streams.

6. Reforestation

BMPs are not necessary for hand planting and direct seeding because these activities pose no threat to water quality. Mechanical planting should be done along the contour.

7. Forest Protection (Prescribed Burning and Firelines)

Prescribed burning should be carefully planned and executed, observing weather conditions. Firelines should follow the contour as much as possible. On grades greater than 5 percent, water bars should be installed in the firelines at frequent intervals.

8. Chemical Treatment (Pesticides)

Federal laws requiring application by trained and certified licensees following label instructions should be adhered to at all times.

State Contact:

Frank Green

Georgia Forestry Commission

(912) 751-3485

Other Available State Information

Manuals/ *Best Management Practices for*
Books *Forested Wetlands in Georgia*
(1990)

Brochures *BMPs for Road Construction*
and Timber Harvesting
Practices in Georgia; BMPs for
Site Preparation, Reforestation
and Chemical Treatments in
Georgia; BMPs along Trout
Streams in Georgia

Videos *Video entitled BMP is Not a*
Four Letter Word

IDAHO

Reference: Idaho Department of Lands. 1992. *Rules and Regulations Pertaining to the Idaho Forest Practices Act Title 38, Chapter 13, Idaho Code.*

Before commencing a forest practice or a conversion of forest lands, the Department of Lands must be notified using forms prescribed and provided by the Department. Notification is required for the following types of practices:

- the harvesting of forest crops including felling, bucking, yarding, decking, loading, and hauling; and road construction or improvement including installation or replacement of bridges, culverts, or structures that convey stream flows within the area described;
- road construction or reconstruction of existing roads including installation or replacement of bridges, culverts, or structures that convey stream flows not within operation areas associated with the harvesting of forest tree species;
- reforestation;
- application of pesticides and fertilizers for the purpose of growing or managing forest tree species;
- pre-commercial thinning; and
- clearing forest land for conversion to nonforest use.

BEST MANAGEMENT PRACTICES

1. Timber Harvesting
2. Road Construction and Maintenance
3. Reforestation
4. Use of Chemicals
5. Slash Management
6. Practices Bordering Stream Segments of Concern
7. Petroleum Products

1. Timber Harvesting

Prior to timber harvest, establish streamside protection zones to protect streambeds and streamside vegetation and to maintain water quality and aquatic habitat. Minimize disturbance to stream bank vegetation and the stream channel when cable yarding across or inside the stream protection zone. Protect the large organic debris, shading, soil stabilization, wildlife cover, and water filtering effects of vegetation along Class I streams. Retain 75 percent of current shade over the stream. Within 50 feet of the ordinary high water mark on both sides of Class I streams, standing trees must be retained according to the requirements presented in Table 9.

For each harvest operation, minimize erosion by selecting the logging method and type of equipment adapted to the given slope, landscape, and soil properties. Do not conduct tracked or wheel skidding in streams, on slopes exceeding 45 percent gradient immediately adjacent to Class I or II waters, or on geologically unstable, saturated, or easily compacted soils. Tractors used for skidding must be limited to the size appropriate for the job. Uphill cable yarding is preferred, but where downhill yarding is used, minimize downhill movement of slash and soils by lifting the leading end of the log.

Table 9. Minimum Standing Trees per 1000 Feet (Each Side)

Tree Diameter (DBH)	Stream Width (feet)		
	Over 20	10-20	Under 10
0-7.9"	200	200	200
8-11.9"	42	42	42
12-19.9"	21	21	--
20"+	4	--	--

Carefully harvest mature timber from streamside protection zones. Trees must be felled, bucked, and limbed in such a manner that the tree or any part of it will fall away from any Class I streams. Continuously remove slash that enters Class I streams as a result of harvesting operations, and place material at least 5 feet above the ordinary high water mark. Slash and other debris that enters Class II waters should be removed if there is the potential for the material to move downstream or obstruct stream flow.

Locate landings, skid trails, and fire trails on stable areas outside the appropriate stream protection zones. Avoid stream crossings, but when necessary install adequately sized temporary structures perpendicular to the stream flow. Locate skid trails where sidecasting is held to a minimum. Minimize the number and widths of skid trails, and minimize the size of landings. On geologically unstable, saturated, highly erodible, or easily compacted soils, limit the grade of skid trails to 30 percent. To prevent landslides, fill material used in landing construction must be free of loose stumps and excessive accumulations of slash. On slopes where sidecasting is necessary, stabilize landings by using seeding, compaction, rip-rapping,

benching, mulching, or other suitable means. Deposit waste materials from construction or maintenance of landings and trails in geologically stable locations outside of the stream protection zone. For each landing, skid trail, or fire trail, provide and maintain a drainage system that will control the dispersal of surface water to minimize erosion. These measures can include installing water bars or cross drains, establishing ground cover, or regrading landing or trail surfaces.

2. Road Construction and Maintenance

Plan transportation networks to minimize road construction within stream protection zones. Plan each road to the minimum design standards adapted to the terrain and soil materials to minimize disturbances and damage to forest productivity, water quality, and wildlife habitat. Minimize the volume of excavation material by designing the road alignment to fit the natural terrain features and by balancing cuts and fills. Design roads to drain naturally by out-sloping or in-sloping with cross drainage and by grade changes. Plan relief culverts and roadside ditches whenever reliance on natural drainage would not protect the running surface, excavation, or embankment. Stream crossings should be minimum in number and in compliance with the minimum standards for stream channel alteration established under title 42, chapter 38, Idaho Code. Design culverts for stream crossings to carry the 50-year peak flow. Specifications for culvert sizing are provided in the Rules and are based on region and watershed drainage area. The minimum culvert size is 18 inches in diameter. Crossing structures must provide for fish passage along Class I streams.

Construct roads to follow design plans. When constructing road fills near streams, compact the material. Do not incorporate woody material into fills, and minimize the amount of

snow, ice, or frozen soil buried in embankments. Construct cross drains and relief culverts to minimize erosion of embankments, and use rip-rap, vegetative matter, downspouts, and similar devices to minimize erosion of the fill. Stabilize exposed materials by seeding, mulching, rip-rapping, or other means. Postpone construction during wet periods if erodible material would enter streams.

Conduct regular preventive maintenance operations to avoid deterioration of the roadway surface and to minimize disturbances and damage to forest productivity, water quality, and fish and wildlife habitat. During and upon completion of seasonal operations, the road surface must be crowned, out-sloped, in-sloped, or water barred, and berms must be removed from the outside edge except those intentionally constructed for protection of fills. Maintain the road surface to minimize erosion of the subgrade and to provide proper drainage. Keep culverts and ditches functional. When road surface stabilization materials are applied, prevent their entry into surface waters. Following termination of active use, the road surface should be crowned, out-sloped, in-sloped, or water barred, and ditches and culverts should be cleared. Restrict access of vehicular traffic. When permanently abandoning roads, control erosion by out-sloping, water barring, or seeding; clean ditches; restrict access to the road; and remove bridges and culverts unless they will be maintained.

Roads that will be used for winter operations must have adequate surface and cross drainage installed prior to winter operations. This can include rolling dips, driveable cross ditches, open-top culverts, and outsloping. Maintain and drain road surfaces during thaws by performing active maintenance on existing drainage structures, opening drainage holes in

snow berms, and installing additional cross drainage as needed.

3. Reforestation

Reforestation is required on all nonexempt forest land within five growing seasons after a forest harvesting practice reduces the number of acceptable tree species below the acceptable minimum stocking level. Stocking levels and exemptions are provided. Where reforestation is not being planned, vegetative cover must be established within 1 year of completion of harvesting operations on disturbed areas larger than 1 acre.

4. Use of Chemicals

Chemicals should be used in accordance with the requirements of the Idaho Pesticide Law Regulations (title 22, chapter 34, Idaho Code). Equipment used for transportation, storage, or application must be maintained in leakproof condition. When chemicals are mixed with water, provide an air gap or reservoir between the water source and the mixing tank, and use uncontaminated pumps, hoses, and screens. Mix chemicals and clean tanks only where possible spills would not enter water bodies.

Apply chemicals in accordance with manufacturer's label instructions and all state and federal requirements. Carefully plan aerial and ground applications to avoid direct and indirect entry of chemicals into surface waters. For aerial applications, use a bucket or spray device capable of immediate shutoff, and shut off application during turns and over open water. A buffer strip must be maintained on each side of Class I streams, flowing Class II streams, and other areas of open water. Table 10 contains the minimum required buffer widths.

Table 10. Minimum Buffer Widths for Chemical Applications

Application Method	Width (feet)
Aerial application	100
Aerial application of pelletized fertilizer	50
Ground application with power equipment	25
Ground application of fertilizer with power equipment	10

Maintain a record of all aerial chemical applications and ground applications on areas greater than 20 acres and retain for a period of 3 years. If any hazardous chemical is accidentally spilled, contain and neutralize the chemical in accordance with applicable state and federal laws and immediately notify the director of the Department of Lands.

5. Slash Management

Manage slash and fire hazards (fuels and debris) generated from harvesting, forest management, or defoliation caused by chemical applications in that manner necessary to protect reproduction and residual stands; to reduce risk from fire, insects, and disease; and to maintain air and water quality, and fish and wildlife habitat. A point system has been established to determine potential fire hazards and hazard reductions and/or offsets.

6. Practices Bordering Stream Segments of Concern

A forest practice may not be conducted in an area bordering a stream segment of concern until the Department has received and formally accepted notification. The Department must review watershed goals and objectives and

landowner management plans and if necessary, must meet with the appropriate local working committee to determine site-specific BMPs necessary to achieve water quality and fishery objectives. A written agreement must be signed by the landowner and an authorized representative of the Department. This agreement constitutes formal acceptance of the forest practice notice.

7. Petroleum Products

Equipment used for transportation or storage of petroleum products must be maintained in a leakproof condition. Locate storage containers with capacities greater than 200 gallons at least 100 feet from water bodies. Construct dikes or berms around storage tanks that are sufficiently impervious and have adequate capacity to contain spills. Contact the Director immediately in the event of a spill. Fueling operations or transfer of petroleum products to other containers must be constantly monitored. Do not place wastes from logging operations, such as crankcase oil, filters, and grease and oil containers, inside Class I or II stream protection zones.

State Contact:

Jim Colla
Idaho Dept. of Lands
Box 670
Coeur D'Alene, ID 83814

ILLINOIS

Reference: Recommended Best Management Practices for Forestry. *Illinois 208 Water Quality Management Plan*, pp. 337-358.

BEST MANAGEMENT PRACTICES

1. Forest Management Planning
2. Road Systems
3. Drainage Systems
4. Logging Systems
5. Streamside Management Zones
6. Site Disturbance
7. Pesticide Use
8. Fertilizer Use

1. Forest Management Planning

Forest management plans should be developed for all forested areas and should be periodically revised and updated. Road systems should be planned, and planning should be completed prior to construction and harvesting.

Road systems should be designed to fit the topography and follow the contour. The design should minimize road lengths and density, as well as minimizing soil disturbance. The design should also minimize large cuts and fills immediately adjacent to stream channels.

Natural drainage systems should not be disturbed. Drainage plans for road systems should ensure that road drainage is properly dispersed onto stable forested areas and does not flow directly into streams.

Timber harvest plans should be drawn up so that harvest areas are located and laid out to

minimize the intensity of activities in high-hazard areas. Fragile or highly sensitive soil areas or areas with extremely steep slopes should be harvested only with a logging system that minimizes site disturbance.

Logging systems, cutting area, landings, and skid trails should be designed and located so as to avoid fording across streams and to minimize disturbance to streambeds and banks. Stream channels should not be used as skid trails, and stream crossings should be kept to a minimum.

2. Road Systems

Avoid high-hazard areas when locating logging roads. Locate logging roads on benches or ridges and avoid paralleling stream channels. Locate roads such that there are discontinuous grades and suitable drainages. Avoid long, steep gradients. Minimize wet-weather road building and the area of bare soil subject to uncontrolled runoff. Keep road gradients below 10 percent, and spread 2-6 inches of gravel over the roadbed on flat terrain with poor drainage. Construct drainage ditches so that water does not flow directly into a stream. Do not dump slide debris or excess fill material within the high water zone of streams.

Culverts and bridges should not constrict channels and should be designed to pass flood-level waters. Stream crossings should be kept to a minimum and should be located at right angles to the channel and at stable bank locations. Avoid stream channel disturbance, and use vegetative cover to stabilize stream banks. Align culverts parallel to streams. Clear stream channels of all debris produced during construction. Maintain the integrity of logging roads; do not use roads when the roadway is soft. Close roads to vehicular traffic upon completion of logging operation. Revegetate closed road areas and remove bridges and culverts.

3. Drainage Systems

Properly design and install drainage ditches, and divert drainage water into stable, vegetated areas, sump holes, or settling basins to remove sediments. Do not locate logging roads and landings in natural drainage ways or in unstable areas. Inspect and clear drainage systems periodically.

4. Logging Systems

Minimize site disturbance and remove tops from drainageways. Locate skid trails on the contour and avoid high-hazard areas. Keep the trail grades low. Minimize the number and length of skid trails. Avoid skidding across streams, and do not allow skidders on trails in wet weather. Properly maintain skid trails. Locate landings in stable areas away from streams and drainage ways. Restrict logging equipment to firm, stable areas, and do not service equipment in locations adjacent to lakes, rivers, streams, or drainage ditches.

5. Streamside Management Zones

Leave streamside management zones of sufficient width along sides of all perennial streams, and exclude skidders and logging equipment from SMZs. Leave sufficient streamside vegetation to shade temperature-sensitive waters. Do not allow tops and other logging debris to enter the waters of perennial streams, and do not dump slide debris or excess fill within the high water zone of streams. Do not use mechanical site preparation within 100 feet of streams or other bodies of water. Avoid fertilizer or pesticide application in the SMZ.

6. Site Disturbance

Minimize disturbance of the soil and the forest floor. Convert marginal cropland, steep slopes, and sensitive areas to permanent forest

cover. Evaluate the erosion potential of soils with soil surveys and the Universal Soil Loss Equation (USLE). Perform site preparation on the contour, and perform work during dry weather.

7. Pesticide Use

Only use approved and registered pesticides, and use them in strict accordance with regulations and manufacturer's directions. Minimize application and/or prevent direct discharge into streams or other water bodies. Provide safe storage and do not service equipment in locations adjacent to streams or other water bodies. Do not apply pesticides immediately before heavy rain. Dispose of equipment rinse water in areas where it will not contaminate any water body.

8. Fertilizer Use

Apply fertilizers during maximum uptake periods. Do not apply directly to, or allow fertilizer to drift into, any water body. Apply fertilizer only on the basis of need to correct nutrient deficiency. Do not apply it immediately preceding heavy rain. Properly dispose of equipment rinse water fluids.

State Contact:

Pete Skuba
Forest Protection Program Manager
Illinois Dept. of Conservation
(217) 782-2361

or

Rick Mollahan
Illinois EPA
(217) 785-3958

INDIANA

References: Indiana Department of Natural Resources, Division of Forestry. *Logging Roads and Skid Trails: A Guide for Soil Protection and Timber Management*; and Indiana Department of Natural Resources, Division of Forestry. 1992. *Best Management Practices: Protecting the Woods While Harvesting - Final Draft*.

The Indiana Classified Forest Act requires program participation to follow a forest management plan in exchange for a lowered tax assessment and free forest inspections every 5 years. The Act requires "watershed protection" and plans generally address BMP's in relation to soil erosion and timber harvesting. The Indiana Flood Control Act (I.C. 13-2-22) prohibits any fill or obstruction that would "adversely affect the efficiency of or unduly restrict the capacity of a floodway."

BEST MANAGEMENT PRACTICES

1. Planning Road Locations
2. Logging Operations
3. Closing Roads and Trails After Logging
4. Bridges and Culverts
5. Buffer Strips
6. Waste Disposal

1. Planning Road Locations

Prior to commencing harvesting operations, plan the location of logging roads, skid trails, and loading areas. Locate roads and trails on side slopes, and avoid ridge tops or flats where water cannot drain properly. Do not locate skid trails directly up-slope. Design roads and trails at a 2 to 10 percent grade, and allow

grades of 15 to 20 percent only for short distances. Grades of less than 1 percent will result in poor drainage. Avoid stream crossings, but when necessary, locate crossings at right angles to stream flow where approaches are level for at least 50 feet on both sides. Loading areas should have slopes between 2 and 4 percent and should be located on well-drained soils. Leave a buffer strip of undisturbed land between watercourses and logging roads, skid trails, and loading areas.

2. Logging Operations

Minimize the area disturbed by road, trail, or logging yard construction. Do not locate logging yards within 50 feet of a perennial or major intermittent stream. Because skid trail surfaces are constantly disturbed during skidding, the best methods of controlling water on skid trails are the proper initial placement of skid trails and the maintenance of natural drainages. Do not operate equipment when rutting in excess of 8 inches is occurring.

Use drainage dips to divert water flow off steep or long road grades. Construct dips on grades of 10 percent or less. The recommended spacing of drainage dips is provided in Table 11.

Table 11. Drainage Dip Spacing

Road Grade (percent)	Distance Between Dips (feet)
1	500
2	300
5	180
10	140

Periodically clean drains and perform maintenance to roads and skid trails. Gravel portions of roads most sensitive to erosion.

Avoid logging in or close to streams, and prevent tops and slash from entering streams. Remove all stream flow obstructions created by the harvest.

3. Closing Roads and Trails After Logging

Upon completion of harvesting operations, repair drainage dips on logging roads and remove temporary structures. Construct water breaks on skid trails where water control is needed. Water breaks should be angled 30 degrees downslope and should extend 1 to 2 feet on either side of the skid trail. The recommended spacing between water breaks is provided in Table 12.

Table 12. Water Break Spacing

Skid Trail Grade (percent)	Distance Between Water Breaks (feet)
1-2	500-250
3-5	250-125
5-10	125-80
11-15	80-60
16-20	60-40
21-30+	40-30

Smooth and out-slope rutted skid trails and logging roads to a 2 to 3 percent grade. Smooth log landings and clear debris. Seed and/or mulch heavily traveled steep areas, log landings, and stream approaches. Remove slash from streams before leaving the area. Restrict access to the harvested area.

4. Bridges and Culverts

Minimize the number of stream crossings required for the harvest. Use bridges, culverts, or solid rock ford when crossing large streams. A permit from the Department of Natural Resources may be required for

construction of a stream-crossing structure. Locate bridge crossings perpendicular to stream flow where the stream channel is straight, flow is unobstructed, and the approaches are fairly level for a minimum of 50 feet on both sides. Place abutments parallel to stream flow. Install culverts at a 30 degree angle downslope, and keep them clear of debris. Do not use open-top culverts on skid trails.

5. Buffer Strips

When harvesting near water bodies, watercourses, cave openings, or other sensitive areas, retain a buffer strip of at least 50 feet where little or no harvesting activity will occur. This area can also be referred to as a streamside management area. Harvesting within the buffer strip should be limited to 50 percent removal of the canopy cover. Remove any tree tops from surface waters and place at least 50 feet from the water's edge. Do not locate haul roads, skid trails, or landings in buffer strips.

6. Waste Disposal

Do not allow toxic wastes to enter forest soils or surface waters. Carefully refuel equipment to avoid spills; this applies to chainsaws as well as larger equipment. When changing fluids, drain them into containers and remove them for recycling or proper disposal. Remove all trash from the harvesting site.

State Contact:

Daniel Ernst
Dept. of Natural Resources
(317) 232-4106

KENTUCKY

Reference: Kentucky Department for Natural Resources and Environmental Protection, Division of Forestry. 1992. *Kentucky Forest Practice Guidelines for Water Quality Management*.

BEST MANAGEMENT PRACTICES

1. Access Roads
2. Skid Roads and Skid Trails
3. Landings and Concentration Yards
4. Vegetative Establishment on Silviculturally Disturbed Areas
5. Livestock Exclusion
6. Fire Lines and Prescribed Burning
7. Site Preparation and Reforestation
8. Fertilization
9. Pesticides
10. Streamside Management Zones
11. Logging Debris and Trash
12. Wetlands

1. Access Roads

Use topography, property lines, and soil surveys to locate roads on low grades and away from streams, rock outcrops, ledges, wet areas, and other obstacles. Retain SMZs between watercourses and roads. Avoid stream crossings, but when necessary cross streams perpendicular to stream flow. The use of temporary bridges or culverts is preferred, but when fords are used on permanent roads, gravel each side where significant soil disturbance may occur. Design cut-and-fill slopes to the normal angle of repose.

If possible, construct roads several months in advance of anticipated use to allow for settling and increased surface stability. Adequate

drainage is the most important factor in controlling soil erosion and keeping a road in serviceable condition. Out-slope the entire width of the road to a slope of $\frac{1}{4}$ inch per foot to reduce the number of drainage structures required. If soil conditions are such that out-sloping the road would reduce safety, in-slope the road and install additional drainage structures. Specifications for constructing and installing culverts, water bars, and drainage dips are provided in the manual. The recommended distance between drainage structures is based on road grade, but actual distance should consider site-specific conditions. Drainage dips should not be installed to accommodate flowing water. Construct bridges only when a stream crossing cannot be avoided by using an alternative road location or when other structures such as culverts cannot be used. Locate bridges perpendicular to stream flow where the stream channel is straight and the approaches are reasonably level for a minimum of 50 feet on both sides. Bridges should not impede natural stream flow.

Periodically inspect and maintain roads. Problem areas having steep road grades and wet areas should be logged during favorable weather conditions to minimize road damage and subsequent repairs. Minimize road use during wet weather unless surface materials permit all-weather use. Maintain a properly functioning drainage system by clearing drainage structures of debris and regrading the road surface. After completion of forest activity, retire access roads by smoothing and reshaping road surfaces, replacing open-top culverts with water bars or drainage ditches, and revegetating road surfaces, road banks, and landings.

2. Skid Roads and Skid Trails

Plan the skid road system prior to beginning harvesting operations. Locate landings first

and lay out the skid road approach with a low grade. Locate skid trails along the contour, avoiding streambeds. Construct skid trails on a slant or zig-zag path, breaking the grade occasionally to avoid long, steep slopes. Install water turnouts and cross drains at the recommended intervals. Minimize the number of stream crossings, and construct small bridges or install culverts at stream crossings, particularly on the main skid road where fording could generate considerable sediment.

When avoidable, do not harvest during wet weather. When skidding, pull logs uphill or along the contour and raise the end of the log to minimize soil disturbance and trench formation. When harvesting around sinkholes, do not push debris or divert water into the sinkhole and be careful of immediate area soil disturbance.

Maintain an effective drainage system on skid trails during harvesting operations. Upon completion of harvesting operations, clear debris from streambeds and restore them to their natural shape and grade, install water bars, and revegetate steep sections of trails. Rocks and logging debris can be used to construct water retardent structures on steep grades.

3. Landings and Concentration Yards

Prevent erosion from landings and yards through proper location and use. Retain adequate SMZs between landings and watercourses. Landings and yards should have a slope sufficient to allow for drainage. Prevent entry of runoff into the landing area by providing adequate drainage on approach roads and constructing a diversion ditch along the uphill side of the landing. Revegetate landings and yards immediately following the completion of forest activities.

4. Vegetative Establishment on Silviculturally Disturbed Areas

When needed and where feasible, grade the area to be vegetated to permit the use of conventional equipment for seedbed preparation, seeding, mulching, and maintenance. If seedbed preparation is not being performed, scarify the soil surface prior to applying seed, lime, and fertilizer. Apply fertilizer and lime at rates sufficient to provide adequate vegetative cover considering site conditions and plant species. Incorporate the fertilizer and lime into the soil to a depth of 4 to 6 inches with a harrow, disk, or rake operated along the contour. Apply mulch to areas that are steep, eroding, or difficult to revegetate. Tables are provided in the manual to determine proper plant selection, seeding dates, and application rates for seed, fertilizer, and mulch.

5. Livestock Exclusion

Use a fence or barrier to protect eroded, newly planted, or rundown areas and areas planted for wildlife food and cover from domestic livestock grazing. Fences are commonly wire but can be constructed of wood or stone. All fences should be built in accordance with good construction principles and workmanship. Specifications for fence construction are provided in the manual.

6. Fire Lines and Prescribed Burning

Construct fire lines around the perimeter of an area to be treated by prescribed burning, and during wildfire control operations or prior to the occurrence of wildfire. Plan and install fire lines to minimize erosion. Locate fire lines along the contour at low grades. Construct fire lines only as deep and wide as necessary to control the fire. Install water bars on fire lines at the same interval recommended for skid trails. Do not drain

runoff directly into streams. Revegetate fire lines where there is the potential for erosion.

Carefully plan prescribed burns to occur during proper weather and fuel conditions and to adhere to State laws regarding burning and air pollution. Execute burning only with trained personnel under carefully prescribed conditions of humidity, temperature, and wind. When piling and burning, avoid streambeds, minimize incorporation of soil into the piles, and construct piles along the contour. Retain a filter strip between the burned area and watercourses.

7. Site Preparation and Reforestation

Choose the type and intensity of site preparation that will minimize soil disturbance and adverse water quality impacts. Methods selected should be based on the amount, size, and type of vegetation present, slope gradient, and erodibility of the soil. Use low impact site preparation methods where possible. Favor chemical treatments over mechanical methods on steep slopes (those exceeding 30 percent) and highly erodible soil. Table 13 lists various site preparation methods and their potential to impact water quality.

Always establish SMZs between watercourses and site-prepared areas. Use hand methods next to streams or on steep slopes. Operate site preparation machinery along the contour. Operate a mechanical tree planter on the contour to prevent erosion and soil movement originating from the planting slit created by the coulter disk on the machine. Avoid operating heavy equipment during wet weather to minimize soil disturbance and compaction. When possible, perform heavy site preparation during the summer and early fall to avoid winter rains and to allow time for loose soil to settle before planting. Provide for temporary vegetative cover of the area if soil will be exposed for long periods of time.

Table 13. Potential Site Preparation Impacts on Water Quality

Site Preparation Method	Water Quality Impact Potential
Herbicide injection	Little or no hazard
Clearfelling with chainsaw	Little or no hazard
Herbicide spraying	Potential, if pesticide BMP not followed
Drum chopping	Medium potential
Drum chopping with burning	Medium potential
Shearing and windrowing	High potential
Disking	High potential

Construct windrows only when necessary. Locate windrows 100 to 300 feet apart along the contour and away from drains and streams. Minimize the incorporation of soil during windrow construction. Provide occasional breaks in windrows to allow access for fire suppression and other vehicles and to prevent damming of water and potential gullying.

8. Fertilization

Fertilization may be accomplished by manual, aerial, or machine application of soluble inorganic compounds or through the application of animal waste. Before any application of fertilizer, perform a soil test to determine which specific soil elements, if any, are lacking. Avoid direct application of fertilizers to water bodies. Additional controlling factors are the elimination of excessive fertilizer applications, the selection of proper fertilizer formulation, and the proper timing and method of application.

9. Pesticides

Use pesticides in accordance with manufacturer's label instructions and all pertinent state and federal laws. Mix pesticides in the correct quantity to minimize excess material. Do not apply near water bodies if a pesticide has aquatic toxicity. Do not clean equipment or dump excess pesticides near water bodies or wells. Use excess spray material in accordance with label instructions or dispose of it according to appropriate regulations. Triple rinse and properly dispose of empty pesticide containers. Develop an emergency plan and maintain absorbent material in case of a spill.

10. Streamside Management Zones

Designate streamside management zones around all watercourses where harvesting and other forestry activities may occur. SMZs should be 30 to 50 feet wide on relatively flat ground and 50 to 90 feet wide on steeper ground. The SMZs widths provided in Table 14 are based on percent slope and are more technical recommendations. Wider SMZs may be necessary if there is great erosion potential from steep slopes or unstable soils.

Retain 50 percent of the tree overstory and stream canopy cover along perennial streams. Winching is the preferred method of removing logs from an SMZ. For streams designated as Coldwater Aquatic Habitats (CAHs), additional protective measures are recommended. These measures include not disturbing understory vegetation that is immediately adjacent to the stream and limiting overstory removal to trees of high commercial value.

Locate roads and landings outside SMZs and as far from streams as practical. Avoid operating logging equipment or other vehicles in SMZs, except at designated stream crossings. Pesticide and fertilizer use in SMZs

Table 14. SMZ Widths

Slope of Land (percent)	Width of Zone (feet)
0	25
10	45
20	65
30	85
40	105
50	125
60	145
70	165

is generally undesirable, but all applications should comply with label directions and should follow recommended BMPs.

11. Logging Debris and Trash

Take precautions to prevent tree debris from falling into or being washed into perennial streams. Fell trees away from drainages and perennial streams, if possible, and remove any accidental debris and place it above the ordinary high water mark. Do not leave equipment on stream banks or change oil or equipment fluids in a manner that causes pollutants to wash into a stream. Properly dispose of trash, such as oil cans, bottles, and lunch bags.

12. Wetlands

Minimize construction of permanent roads. However, when needed, locate roads on the higher ground parallel to the drainage system and use a minimum amount of fill material. Generally, avoid crossing streams and sloughs, but when necessary cross perpendicular to the stream flow, using culverts or bridges without altering natural drainage or disturbing stream

banks and other sensitive areas. Upon completion of forestry operations, temporary roads should be reshaped and revegetated, stream crossing structures should be removed, and access should be restricted.

Establish SMZs of at least 50 feet in width to protect streams, sloughs, and lake banks. Timber may be harvested in the SMZs, but retain 50-75 percent of overstory to shade streams and sloughs. Minimize operation of logging vehicles and equipment.

Plan to harvest during dry weather. Minimize the number and size of landings, and locate them on elevated areas away from streams and SMZs. Restrict vehicle travel to a minimum. Use low-ground-pressure tires on skidders and concentrate skidding to a few primary skid trails. Scarify severely compacted areas on log landings and skid trails and revegetate to prevent erosion and improve wildlife habitat.

Always use pesticides in accordance with label instructions, and adhere to all federal and state policies and regulations. Carefully plan aerial application of pesticides to prevent contamination of streams, ponds, and forested wetlands and to reduce the possibility of damage to nontarget plant and animal life.

State Contact:

Cary Perkins

Kentucky Division of Forestry

(502) 564-4496

LOUISIANA

Reference: Louisiana Department of Agriculture and Forestry and Louisiana Forestry Association. 1988. *Recommended Forestry Best Management Practices for Louisiana*.

BEST MANAGEMENT PRACTICES

1. Streamside Management Zone
2. Permanent Access Roads and Their Construction
3. Timber Harvesting
4. Reforestation
5. Fire Line Construction
6. Forest Chemicals

1. Streamside Management Zones

Establish a zone adequate to protect streambed and stream bank integrity. The larger the stream, the wider the streamside management zone. Locate roads and log decks outside SMZs when possible. Avoid frequent stream crossings and cross only at right angles to the stream flow. When crossing, use culverts, bridges, or fords. Do not leave trees, tops, or temporary crossing materials in watercourses.

2. Permanent Access Roads and Their Construction

Construct a road to sufficiently carry the anticipated traffic load with minimum environmental impact. If possible, avoid building roads in narrow canyons, marshes, wet meadows, natural drainage channels, and SMZs. Locate roads along the crest of long ridges, on the contour, and at a distance sufficient to minimize the impact to streams. Minimize the number of stream crossings, and

cross streams at right angles to the main channel. Timber on road rights-of-way should be removed or decked outside the borrow ditches. Balance cuts and fills, and use the excavated material to avoid creating unnecessary borrow pits. Sidecast or fill material should not be placed below the ordinary high water mark of any stream.

Roads should be designed to drain naturally at all times. Ditches, culverts, and cross drains should be installed at low points in the road gradient. Keep culverts open and clean to permit unrestricted water flow. Protect low water bridges, fills, and earth embankments from high-water erosion. Waste materials and woody debris should be cleared from streams and drainage ways. Bridges should not constrict clearly defined stream channels. Cross streams during periods of dry weather when stream flow and the threat of erosion are minimized.

Revegetate or stabilize exposed soil. Inspect frequently used roads. Crown or out-slope road surfaces and install waterbars, dips, or other diversions to dissipate surface runoff and minimize roadbed erosion. Restrict traffic during periods of excessive ground moisture if such restriction is practical.

3. Timber Harvesting

Harvesting operations should be planned and conducted to minimize soil compaction, erosion, and sedimentation. Minimize the number of skid trails and the amount of traffic on steep slopes. Watercourses and streambeds should not be used for skidding or forwarding, and skidding across streams should be minimized. Skid away from permanent and intermittent streams. Fell trees away from water bodies and remove any debris that gets into water, streams, or drainage courses.

Service equipment away from streams. Dispose of trash and oil properly. Upon completion of operations, condition temporary roads, skid trails, and landings to minimize erosion.

4. Reforestation

Use the minimum site preparation necessary to control competing vegetation and establish a desirable timber stand. Analyze and plan the site preparation methods and equipment to be used, considering soil, topography, competing vegetation, precipitation, and drainage patterns, with special emphasis on protecting SMZs. Use operations that will minimize soil disturbance. Hand planting, direct seeding, or natural regeneration should be used on protected areas adjacent to streams or on slopes too steep to machine plant. When working on slopes, mechanical operations should follow contours. (Drum chopping is an exception.) Windrows and machine planting should also follow the contour. Provide water outlets on bedded areas at locations that will minimize soil movement. Streams should be crossed by equipment only on bridges or fording sites that minimize stream channel disturbance.

5. Fireline Construction

Presuppression firebreaks should be located on the contour as often as possible. Firebreaks on erodible steeper grades should contain waterbars or diversions at frequent intervals. Discharge water into undisturbed vegetation outside the burn, when possible.

6. Forest Chemicals

Landowners must observe all state and federal laws and regulations that cover the purchase, transport, storage, use, and disposal of chemicals. Silvicultural chemicals should be

applied by trained and certified licensees, and all label instructions should be followed.

State Contact:

Donald P. Feduccia
Office of Forestry
(504) 925-4500

MAINE

References: Maine Forest Service. 1991. *Erosion & Sediment Control Handbook for Maine Timber Harvesting Operations Best Management Practices* and the 1989 Forest Practice Act.

The 1989 Forest Practice Act requires notification by the landowner or designated agent to the Bureau of Forestry prior to commencing harvesting operations. Notification must be on forms supplied by the Bureau and must include the following:

- (1) the name, address and phone number of the landowner, any designated agent, and, if known, any harvester(s);
- (2) the name and address of any licensed professional forester consulting the landowner on forest management or harvesting practices;
- (3) the municipality or township and county of harvest;
- (4) the name of the nearest public or private all-weather road;
- (5) the approximate dates the harvest will begin and finish;
- (6) the anticipated acreage to be harvested;
- (7) whether the land is being harvested to convert to another use within 2 years and, if so, what that use is to be;
- (8) the signatures of the landowner or designated agent; and
- (9) a map locating the harvest site in relation to known or easily identifiable terrain features, such as a road junction or a stream and road junction.

A forest management and harvest plan must be prepared and updated every 10 years for commercial forest land to be taxed as such. The Act defines the forest management and harvest plan as a written document prepared by a licensed professional forester, outlining

activities to regenerate, improve, and harvest a standing crop of timber. The plan must include the location of water bodies and wildlife habitat identified by the Department of Inland Fisheries and Wildlife.

BEST MANAGEMENT PRACTICES

1. Logging Yards and Landings
2. Skid Roads and Skid Trails
3. Truck Roads
4. Broad-Based Drainage Dips
5. Filter Strips
6. Skid Humps
7. Water Bars
8. Bridges (log, metal, or combination)
9. Cross Drainage Culverts
10. Streambed Culverts
11. Pesticides
12. Oils, Fuels, Coolants, and Hazardous Wastes
13. Protection of Permanent Streams and Water Bodies from Temperature Increases or Siltation
14. Seeding and Revegetation
15. Slash
16. Temporary Sand-Salt Storage Areas
17. Sediment Barriers

1. Logging Yards and Landings

Locate yards and landings away from streams, ponds or lakes, very steep areas, wet areas, and filter strips. Landings should be located on gently sloping and higher ground with good drainage. Size landings to meet the needs of the harvesting operation. Divert water draining from landings so that it does not enter truck roads or skid trails or flow into streams, ponds, lakes, or wetlands, but flows onto undisturbed forest floor. Oil, transmission fluid, antifreeze, and other toxic products should be disposed of in accordance with

approved procedures. Upon completion of operations, clean up the landing area and stabilize the soil to prevent erosion.

2. Skid Roads and Skid Trails

Routes should be planned to be the most direct and take advantage of natural features that will make construction and drainage easier while avoiding long, steep grades, sharp bends, wet areas, streams, ponds, and lakes. Sensitive areas should be logged during periods of dry weather or when the ground is frozen. Keep stream crossings to a minimum, and cross at right angles where the approaches are reasonably level for a minimum of 50 feet on both sides. Crossings should not impede water flow or fish passage, and disturbance to the streambed and banks should be minimized. Upon completion of operations, revegetate and mulch unstable areas, install water diversions, and place slash on skid trails to slow runoff.

3. Truck Roads

Minimize the length of road required from landing to public highway. Avoid watercourses, water bodies, wet areas, steep terrain, sharp curves, hard bedrock, game management areas, and long, level sections of road that are difficult to drain. Crown roads, where possible, and provide drainage ditches, water diversion structures, and sediment traps as necessary. Revegetate or stabilize all cut or fill banks and areas of exposed mineral soil outside the roadbed. Road banks should not have a slope steeper than 2:1. Keep stream crossings to a minimum, and cross at right angles where the approaches are reasonably level for a minimum of 50 feet on both sides.

4. Broad-Based Drainage Dips

Broad-based drainage dips should be installed in roads with long slopes of less than

10 percent and spaced no farther apart than the distance indicated in Table 15. Discharge should be diverted to an undisturbed vegetated area, and the discharge area should be protected with stone, grass, sod, heavy litter, and slash or logs.

Table 15. Broad-Based Dip Spacing

Road Grade (percent)	Spacing (feet)
0-2	500-300
3-5	250-180
6-10	167-140

5. Filter Strips

Locate areas to be maintained as filter strips (next to streams, lakes, etc.) and determine appropriate width using Table 16. With the exception of intermittent streams, no more than 40 percent of the total volume of timber 6 inches DBH and greater within the filter strip should be removed in a 10-year period, and the trees removed should be reasonably distributed throughout the filter strip. Avoid felling trees into or across watercourses and water bodies. Do not disturb the topsoil or duff within the filter strip.

Table 16. Filter Strip Widths

Slope of Land (percent)	Width of Strip (feet)
0	25
10	45
20	65
30	85
40	105
50	125
60	145
70	165

6. Skid Humps

Use natural humps or rises in the landscape wherever possible. Table 17 provides appropriate spacing for skid humps according to grade.

Table 17. Skid Hump Spacing

Road Grade (percent)	Spacing (feet)
1-2	300
3-10	150
11+	100

7. Water Bars

Upon completion of operations, install water bars at the top and bottom of steep sections of skid roads and trails, starting at the end of the road and working back toward the log yard and truck road. Install water bars at an approximate 30-degree angle downslope from a line perpendicular to the center line of the road. Table 18 contains the recommended spacing for water bars. Stabilize water bars by revegetating the surface. Place rocks, slash, or logs at outlet to disperse and filter the water.

Table 18. Water Bar Spacing

Road Grade (percent)	Spacing (feet)
1-2	250
3-5	200-135
6-10	100-80
11-15	80-60
16-20	60-45
21+	40

8. Bridges

Bridges should be located where the water channel is straight and unobstructed and where the road would cross at right angles. The banks should be firm and level and have approaches that are of shallow slope. Adequately size the bridge to accommodate anticipated stream flows, traffic volume, types of traffic, and weight of loads. Seed and mulch any disturbed areas outside the roadbed to minimize erosion. Placement of bridges that require work in the stream should be done when the water level is low and as quickly as possible. The use of portable bridges is encouraged for small stream crossings. Maintain bridges with periodic inspections and removal of any debris that may hinder stream flow.

9. Cross Drainage Culverts

Determine areas where cross drains are needed, and adequately size culverts to accommodate anticipated flow volumes. A 15-inch culvert is the recommended minimum. Table 19 contains the recommended spacing for cross drainage culverts based on road grade. Install culverts at least 12 inches below the road surface, and on slopes in excess of 10 percent, install them at a 30-degree angle downslope. Stabilize the shoulders of culverts with stone. Establish a periodic inspection schedule to maintain the culverts' functionality.

10. Streambed Culverts

Adequately size culverts to accommodate anticipated stream flows, and the volume and types of traffic. The culverts should not restrict the water flow or fish passage. Install culverts so that both ends extend a foot beyond the toe of the fill and the bottom is at or a little below the streambed. Rocks should be

Table 19. Cross Drainage Culvert Spacing

Road Grade (percent)	Spacing (feet)
0-2	500-300
3-5	250-180
6-10	167-140
11-15	136-140
16-20	125-120
21+	100

placed under any downstream outfall to prevent undercutting. Revegetate exposed soils after the construction has been completed. Maintain culverts by removing obstructions and cleaning inlet and outlet areas.

11. Pesticides

Contact the Board of Pesticide Control prior to application. Commercial pesticide applicators must be licensed and certified by the Board.

12. Oils, Fuels, Coolants, and Hazardous Wastes

Federal and state law forbids the disposal of oils, fuels, coolants, or hazardous wastes by pouring them into or onto the ground, or into water bodies. Provide for the collection and safe disposal of all hazardous wastes during maintenance and repair. In the event of a spill, contain the spill by blocking its flow to surface waters, use hay or other absorbent materials, and contact the Department of Environmental Protection.

13. Protection of Permanent Streams and Water Bodies from Temperature Increases or Siltation

Designate an area of vegetation to remain undisturbed during harvesting to ensure canopy shading of the stream and filtration of runoff.

The on-site planner should use best professional judgment to determine the size of the area required to provide adequate shading. This decision should be based on site conditions, such as stream width and depth, depth of the canopy, and relative position of the sun along the course of the stream.

14. Seeding and Revegetation

Seed or otherwise revegetate disturbed and exposed areas where there is serious potential for soil erosion and where conditions are less favorable for the invasion of native vegetation, such as large areas, infertile sites, and arid sites. Select a seed mixture that will grow on the site. A soils test may be required. Mulch the seeded area to prevent erosion prior to establishment of vegetation. Periodically inspect the seeded area, and if necessary reseed bare spots or use lime and fertilizer.

15. Slash

Plan harvesting activities to avoid slash disposal in water bodies and to use slash for erosion control. Use directional felling to avoid placing slash in water bodies. If slash does fall into a water body and must be removed, use winches or other methods that will not damage the filter strip or stream banks. Use slash to control erosion and sediment and to create surface for skid roads.

16. Temporary Sand-Salt Storage Areas

Strategically locate storage areas to minimize the number required. Locate them on flat areas close to the road where containment features may be constructed to prevent runoff, but away from water bodies and aquifer recharge areas. Construct a berm of sufficient height around the storage area to contain precipitation that may collect in the storage area. Use heavy plastic (or other impermeable material) as a cover and a liner to minimize

penetration into ground water. Be careful to not puncture the liner when removing salt or sand. Upon abandoning the storage site, properly dispose of the remaining contents and liner, and regrade and revegetate the site.

17. Sediment Barriers

Sediment barriers are temporary structures that may consist of filter fences or straw or hay bales. The effectiveness of the sediment barrier is completely dependent on its installation. All sediment barriers need to be firmly anchored and supported. Maintenance of the structure is necessary, especially after storms and runoff events. Sediment deposits should be removed before one-half height of the barrier is reached.

Straw/hay bales should be placed in a single row, lengthwise on the contour with the ends of the bales tightly abutting each other. Bales should be bound and placed in a trench at least 4 inches deep. Filter barriers and silt fences may be constructed using burlap or standard synthetic filter fabric.

State Contact:

Ancyl S. Thurston
Bureau of Forestry
(207) 287-2791

Other Available State Information

Manuals/ Books	<i>Best Management Plans</i> (1992); <i>Lesson Plan for BMPs</i> (1992)
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MARYLAND

References: Maryland Department of Natural Resources. 1992. *Maryland's Guide to Forest Operations and Best Management Practices*; and Maryland Department of the Environment and the Maryland Forest Service. *Soil and Erosion Control Guidelines for Forest Harvest Operations in Maryland*.

Maryland state law and regulations require that a sediment control plan be developed and approved before undertaking any earth-disturbing activity in excess of 5,000 square feet. Harvests on private property require plan approval by the local Soil Conservation District, and harvests on state and federal land require plan approval by the Maryland Department of the Environment. The Standard Plan for Forest Operations emphasizes sediment control at access points to the site; on roads, trails, and landings; and adjacent to watercourses. The Standard Plan requires that uncut buffer zones (SMZ) be maintained on all sides of perennial or intermittent streams, rivers, lakes, ponds, bogs, and marshes. Harvesting is allowed within the SMZ provided that a Buffer Management Plan is prepared by a licensed forester.

The Maryland Nontidal Wetlands Protection Act and Regulations requires the implementation of best management practices when conducting forestry activities in nontidal wetlands. These BMPs must be incorporated into the Standard Plan prepared by a licensed forester and must be submitted before beginning the harvest.

The Chesapeake Bay Critical Area is the land within 1,000 feet of the Chesapeake Bay and its tidal waters or tidal wetlands. For 1 acre or more of forest in the Critical Area to be cut within any 1-year interval, a Timber Harvest Plan must be prepared and approval granted by

the Maryland Forest Conservancy District Board before any timber can be harvested.

The Maryland Department of Natural Resources, Water Resources Administration, requires that a Waterway Permit be obtained prior to the construction of a stream crossing if the drainage area above the crossing exceeds 400 acres or exceeds 100 acres for designated trout streams.

BEST MANAGEMENT PRACTICES

1. Preharvest Planning
2. Truck Haul Roads
3. Skid Trails
4. Log Decks, Landings, and Portable Sawmill Locations
5. Streamside Management Zones
6. Drainage Structures
7. Stream Crossings
8. Site Preparation
9. Revegetation of Bare Soil Areas
10. Wildfire Control and Reclamation

Forested Wetlands

11. Natural Regeneration
12. Preharvest Planning
13. Truck Haul Roads
14. Skid Trails
15. Log Decks
16. Streamside Management Zones
17. Cross Drainages

1. Preharvest Planning

The objective of preharvest planning is to determine which BMPs are necessary to protect water quality and how those BMPs will be implemented. Preharvest planning may be primarily verbal, but use of a written contract is encouraged. Depending on the site and

nature of the harvest, the plan should include any or all of the following: property boundaries, streams and drainages, soil restrictions, slope, environmental concerns, approximation of main haul road and skid trail locations, potential log landings, portable sawmill locations, stream or drainage crossings, and streamside management zones. A site review should be performed to aid in determining potential road locations, log landings, streams, and wet areas. Preharvest planning should include full consideration of site preparation activities.

2. Truck Haul Roads

Truck haul roads should be located on side slopes and away from SMZs and floodplain soils. Roads should follow the contour as much as possible with grades between 2 and 10 percent. Steeper gradients are permissible for short distances not exceeding 200 feet. On soils with severe erosion hazard, grades should be 8 percent or less, but grades exceeding 12 percent for 150 feet or less may be acceptable as long as measures are taken to prevent erosion. Avoid constructing roads that require high cut banks. Vertical road bank cuts should normally not exceed 3 feet, but if the bank cuts are more than 5 feet, they should be sloped to at least a 2:1 ratio and seeded to prevent erosion. Out-slope the road where gradient and soil type will permit. Use cross drainage on in-sloped or crowned roads to reduce runoff travel distance.

Ensure good drainage with properly constructed and spaced turnouts, broad-based dips, rolling dips, culverts, and bridges. Use bridges, culverts, or rock fords to cross intermittent and perennial streams. Streams should be crossed at right angles, and structures should not impede stream flow or fish passage. Fords may be used when stream banks are stable, stream bottoms are hard, and

increased sedimentation will not occur. Install water turnouts prior to a stream crossing to direct runoff into undisturbed areas of the SMZ. Turnouts will be constructed so water will be dispersed and will not cut a channel across the SMZ.

A routine inspection schedule should be established to ensure proper road maintenance. Roads should be free of obstructions, ruts, and logging debris, and drainage structures should be clear. Restrict traffic during unfavorable conditions, such as saturated soil conditions. Upon completion of silvicultural operations, reshape the roadbed and seed all areas of bare soil subject to erosion.

3. Skid Trails

Locate log landings first and plan major skid trails to reduce erosion and sedimentation. Locate skid trails outside SMZs and use a zig-zag pattern climbing up-slope to avoid long, steep grades. Gradients should not be steeper than 15 percent, but steeper segments may be necessary to avoid boundary lines or sensitive areas. If steeper grades are required, practices must be used to prevent gully erosion.

Avoid stream crossings when possible, but when necessary use a bridge or culvert of acceptable design to cross perennial and intermittent streams and drainage ditches that lead to natural drainages. Water crossings should be at right angles. Do not skid logs through streams or when soils are saturated.

Upon completion of skidding, install waterbars at the recommended intervals. Establish vegetative cover on skid trails greater than 5 percent slope or subject to erosion. Scatter logging slash or mulch to supplement waterbars and seeding.

4. Log Decks, Landings, and Portable Sawmill Locations

Locate sites for decks and portable sawmills prior to road construction. Decks, yards, and sawmill sites should be located at least 50 feet outside the SMZ and should be on well-drained soils with a slight slope (2-5 percent) to enhance drainage. Provide for adequate drainage on approach roads and skid trails, such as a diversion ditch around the uphill side of a deck to intercept water flow and direct it away from the deck. Locate residue piles outside wet weather drainages. When servicing equipment, properly drain waste products into containers and dispose of them in accordance with proper solid waste disposal procedures. Remove garbage and trash and dispose of them properly. Decks, landings, and portable sawmill locations should be stabilized to prevent erosion and sediment loss within the first 15 days of the next seeding season following completion of harvesting operations.

5. Streamside Management Zones

SMZs should have a minimum width of 50 feet on both sides of perennial streams and around open water bodies. SMZs may be desirable on intermittent streams for large drainage areas where wildlife or water quality is a major landowner concern. SMZs are also buffers or buffer management areas. The buffer widths presented in Table 20 are required in the *Compliance Agreement for the Standard Erosion and Sediment Control Plan for Forest Harvest Operations (Standard Plan)*. They are determined by the formula:

$$\text{Buffer width (feet)} = 50 + (4 \times \text{slope } \%)$$

Partial harvesting of the SMZ is acceptable, but a minimum of 60 percent crown cover or 60 square feet of basal area per acre must be

Table 20. Required Buffer Widths

Average Slope (percent)	Width of Buffer (feet)
0	50
1-10	75
11-20	100
21-30	150
31-40	200
41+	250

evenly retained. Limit the use of logging equipment by using dispersed skidding, cable and winch, etc. The forest floor should remain essentially undisturbed, and mineral soil should not be exposed. Remove all harvested tree limbs and tops from the stream. Fertilizer should not be used in SMZs.

6. Drainage Structures

Broad-based dips can be used on truck haul roads and heavily used skid trails that have a gradient of 12 percent or less to provide cross drainage. They should not be used for cross draining spring seeps, intermittent streams, or perennial streams. They should be installed during road construction following the basic clearing and grading phase. Spacing of broad-based dips should be determined by the following formula:

$$\text{Spacing (feet)} = \frac{400}{\text{slope } \%} + 100$$

Install an energy absorber, such as rip-rap, at the outfall of the dip to dissipate water velocity and minimize erosion potential. Surfacing the dip with 3-inch crushed stone may be desirable to prevent rutting.

Rolling dips can be used on truck haul roads and heavily used skid trails that have a gradient of 15 percent or less to provide cross drainage. They should not be used for cross draining spring seeps, intermittent streams, or perennial streams. Install them on roads during construction following the basic clearing and grading phase or on skid trails after logging is completed. Recommended spacing is provided in the guide.

Water bars should be used on roads and skid trails that will not have vehicular traffic. If there is the potential for vehicular traffic, use rolling dips. Water bars should be constructed at an angle of 30 to 45 degrees downslope, with the uphill end of the bar extending beyond the side ditch. The outflow end of the bar should disperse runoff water onto undisturbed forest floor. Recommended spacing is provided in the guide.

Pipe culverts or open-top box culverts can be used for any size operation where cross drainage of storm water is needed on truck haul roads or major skid trails. Pipe culverts should be installed on a 2 to 4 percent grade, skewed 15-30 degrees downgrade, and should be long enough so both ends extend at least 1 foot beyond the side slope of fill material. Box culverts should be installed flush or just below the road surface and skewed 30-45 degrees downgrade. Spacing of culverts can be determined using the formula for broad-based dip spacing. The culvert outfall should be protected to dissipate water velocity and minimize erosion potential. The structure should be maintained by removing sediment, gravel, or logging debris.

7. Stream Crossings

When streams must be crossed by logging equipment, use bridges, culverts, or rock fords. Bridges should be constructed with minimum disturbance to the stream bank,

channel, or adjacent SMZ. Pipe culverts should be installed on a 2 to 5 percent grade and should be long enough so both ends extend at least 1 foot beyond the edge of the fill material. Recommended culverts sizes are based on the acres drained, soil density, and slope. Erosion protection measures should be installed at the culvert outlet to minimize downslope erosion. Rock fords or log fords may be used if no practical alternative exists, but the approaches and stream bottoms must be hard enough so turbid water does not result.

8. Site Preparation

A Forest Management Plan should be prepared prior to any site preparation. This plan will consider the condition of the tract, adjacent property, environmental concerns, water quality, type of harvest, silvics of species to be regenerated, and means of regeneration. Site preparation activities should not be conducted in SMZs.

Prescribed burning should be conducted when soil moisture or weather conditions are sufficient to prevent removal of all surface duff and root mat. Construct firelines around the perimeter of the burn area, and install water bars and turnouts.

Mechanical site preparation should be conducted in a manner that minimizes erosion and water quality impacts. Schedule operations during favorable soil moisture conditions. Drum-chop up and down the slope so the depressions created by the cleats and chopper blades are on the contour, reducing the potential for channeled flow. Disking should be performed on the contour and on slopes of less than 10 percent. When performing shearing, piling, root raking, or bulldozing, if a potential for erosion exists, leave the topsoil and root mat in place to preserve site quality and minimize water quality impact. Bulldozing should be limited

to slopes of 20 percent or less, with a windrow constructed approximately every 200 feet. Windrows should be constructed along the contour with a 20-foot opening for each 300 feet of windrow. Bedding should be performed along the contour if the slope is discernible. Machine planting, subsoiling, and sod scalping should be performed on the contour, and steep slopes should be hand planted.

Application of pesticides and disposal of containers should follow manufacturer's label instructions, and measures should be implemented to prevent pesticides from reaching surface waters by direct application or runoff. Application of fertilizers and disposal of containers must adhere to manufacturer's label instructions. Application rates of fertilizers should be based on soil analysis and developmental needs of the desired tree species. Broadcast application of fertilizers within SMZs is not recommended.

9. Revegetation of Bare Soil Areas

All disturbed areas with a grade of 30 percent or greater must be seeded and mulched within 7 days of disturbance. Upon completion of operations, bare soil areas with grades greater than 10 percent and/or areas of bare soil with erosion potential should be identified for revegetation as the season permits. Lime and fertilizer application rates should be determined by soil type and acidity. Suggested seeding mixtures, rates, and dates are provided in the guide. Mulch should be applied immediately after seeding highly erodible slopes or during adverse soil or weather conditions. Seeded areas should be protected from grazing and unrestricted vehicle use.

10. Wildfire Control and Reclamation

When possible, do not plow firelines directly into streams. If this is unavoidable, revegetate

as soon as possible. Stabilize and revegetate firelines on grades greater than 5 percent. Bare soil should be revegetated and eroding gullies treated. Where timber has been killed, reforestation needs should be assessed.

Forested Wetlands

There may be restrictions on some silvicultural activities dependent upon legal interpretations of wetlands and the conversion from wetland species to other species. Discharge of fill materials into waters of the United States from ditching, or other activities whose purpose is to convert forested wetlands to some other use or where the flow or circulation of the waters may be impaired or the reach reduced, is not permitted under the silvicultural exemptions under the Clean Water Act.

11. Natural Regeneration

Successful regeneration depends on (1) recognizing the site type and its characteristics; (2) evaluating the stocking and species composition in relation to stand age and site capability; (3) planning regeneration options; and (4) using sound harvesting methods. Natural hardwood regeneration uses the normal cycle of wetlands species succession. The harvesting system, which also serves as the regeneration system, must be chosen on the basis of stand and site conditions and landowner objectives. Schedule harvest during the dormant season to take advantage of seed crops and to favor coppice regeneration. Harvest the stand as completely as possible to allow maximum sunlight, and leave stumps at a height of less than 10 inches. Minimize soil degradation from logging and site preparation, especially during saturated soil conditions.

12. Preharvest Planning

Planning provides an organized method for an efficient harvest operation while maintaining

subsurface and surface water quality. The wetlands preharvest plan should include:

- upland preharvest planning considerations;
- establishment of 50-foot-wide SMZs on each side of the main channel or areas of open water;
- location of log decks and main sources of road-building materials;
- identification of main road system on the uplands and development of a tentative road system within the wetlands;
- identification of special equipment required for skidding and hauling or other harvesting methods; and
- identification of potential problems or events that may interrupt logging operations.

Schedule harvesting operations during extreme dry periods or during times that enhance regeneration. Use machinery with adequate flotation devices to minimize the impact on the soil surface or degradation of site quality.

13. Truck Haul Roads

Construct road fills only when absolutely necessary. Road fills should be no more than 2 feet above the natural ground level and should be constructed parallel to the flow of the main channel at least 200 feet from the SMZ. Provide cross drains at a minimum every 100 feet. Use gravel or crushed rock as fill to provide for movement of ground water and to serve as a base for the road. A layer of poles, slabs, or logs laid side-by-side, extending 3-4 feet on each side beyond the width of the roadbed, can provide a base for borrow or fill material. Thick layers of large wood chips used as a roadbed distribute load weight and limit the road's adverse impact.

Use planking or wooden mats to improve the soil's ability to support traffic of heavy loads. Cross streams, sloughs, or existing drainage channels with properly sized culverts or bridges.

The use of oversized or balloon tires is encouraged to reduce compaction and rutting. Move equipment to the uplands during periods of potential flooding and wet periods. Upon completion of harvesting operations, remove temporary drainage structures and obstructions from channels, stabilize roads to prevent erosion and sediment loss, and restrict access.

14. Skid Trails

Plan major skid trails to minimize damage to the residual stand, reduce erosion and sedimentation, maintain surface and subsurface water flow, and provide the most economical method for skidding products. Decide the location of log decks before planning skid trail routes, and locate skid trails outside SMZs. Use sandy sloughs as skid trails when harvesting in peat and muck swamps. Avoid stream crossings unless absolutely necessary, but use a bridge or culvert of acceptable design when a stream crossing is unavoidable. Approaches to water crossings should be at or near a right angle to the stream flow and of sufficient length to allow logs to line up behind the skidder. The use of wide-tracked bulldozers and flotation tires on skidders is recommended.

15. Log Decks

Locate log decks in advance of road construction and on elevated lands of the uplands or higher elevations within large wetland units. Provide for adequate drainage on approach roads and skid trails. Use gravel, borrow materials, slab materials, mats, fabrics, or other material to provide adequate drainage and bearing capacity. Locate residue piles

outside the wetlands or wet weather drainages. Service equipment in such a way that petroleum products and toxics are contained and properly disposed of. Garbage, trash, and inoperable equipment should be removed at the end of the harvesting operation. Stabilize landings within the first 15 days of the next seeding season after completion of the harvest.

16. Streamside Management Zones

The practices recommended for SMZs in wetlands are essentially the same as those for SMZs in upland areas. The use of a grapple skidder is recommended to create less disturbance of the forest floor. Minimize the number of access roads through the SMZ, and stabilize all roads, cuts, and fills in the SMZ.

17. Cross Drainages

Cross drainages can be used for any size operation where drainage is necessary to reduce ponding. Pipe diameter should be a minimum of 15 inches. Recommended pipe/culvert sizes are provided in the guide and are based on acres drained and soil type. Multiple pipes may be used to meet the minimum required diameter. Pipe slope should be just below the streambed gradient, with pipe alignment parallel to the stream course. Pipe length should be long enough so both ends extend a minimum of 1 foot beyond the side slope of the roadbed, and erosion protection should be provided at pipe outfalls.

Other Available State Information

Manuals/ Books	<i>Soil Erosion and Sediment Control Guidelines for Forest Harvest Operations in Maryland</i>
Brochures	<i>Forest Harvest Access Practices (Pocket Guide); How to Get Logging Permits Approved in Maryland's 23 Counties</i>

MASSACHUSETTS

Reference: Kittredge, D.B., Jr., and M.L. Parker. 1989. *Massachusetts Best Management Practices: Timber Harvesting Water Quality Handbook*. University of Massachusetts Cooperative Extension; and the Forest Cutting Practices Act, Massachusetts General Law Chapter 132.

The Massachusetts Forest Cutting Practices Act applies to any commercial cutting of a volume of wood products greater than 25,000 board feet or 50 cords on either public or private forestland and requires landowners to submit a form entitled "Notice of Intent to Cut/Forest Cutting Plan" 10 days prior to the commencement of harvesting operations. This form covers information such as cutting methods; plans for regeneration; roads and skid trails to be designed, built, and maintained to control erosion; filter strips along water bodies; and buffer strips along roads and major water bodies. Special forms for wetlands and steep slopes must be included when appropriate.

BEST MANAGEMENT PRACTICES

1. Skid Road Erosion Control
2. Access Road Erosion Control
3. Erosion Control on Landings
4. Erosion Control for Stream Crossings
5. Filter Strips
6. Wetlands
7. Skid Trail and Landing Seeding
8. Close of Operations

1. Skid Road Erosion Control

The Forest Cutting Practices Act requires that skid roads follow the contour of the

topography as much as possible and have grades less than 10 percent with only short distances of up to a 20 percent grade. On slopes greater than 30 percent, use cut and fill skid roads at a 5 percent grade separated by a slope distance of at least 150 feet. In addition, do not operate skidders on slopes of 60 percent or greater.

Plan the location of skid roads prior to the commencement of harvesting operations. If skidding on steep slopes cannot be avoided, skid in a downhill direction. Slash can be used on skid roads to reduce rutting. Upon completion of the harvesting operation, minimize overland flow and erosion by scattering brush or limbs across skid roads or by revegetating skid roads, and by installing water bars. The Forest Cutting Practices Act requires that water bars be constructed to a depth of 8 to 12 inches, with a 3 percent outslope, and be spaced according to the specifications in Table 21.

Table 21. Required Water Bar Spacing

Road Grade (percent)	Distance Between Water Bars (feet)
1	400
2	245
5	125
10	78
15	58
20	47
25	40
30	35
35	32
40	29

2. Access Road Erosion Control

The Forest Cutting Practices Act stipulates that access roads from the landing to a highway

must be graveled or mulched to prevent mud from being tracked onto the highway. Otherwise, use must be curtailed during wet weather or mud must be promptly removed from the highway. In addition, the Act requires that adequate cross drainage structures be provided and that runoff be discharged into appropriate filter strips or hay bale impoundments. Specifications for design and spacing of broad-based dips, open-top culverts, and pipe culverts are provided in the water quality handbook. Design roads to take advantage of natural dips and variations in terrain. Crown road surfaces and avoid constructing roads with grades greater than 5 percent.

3. Erosion Control on Landings

Locate landings on gently sloping, well-drained soils and at least 100 feet from streams or other water bodies. If landings have to be closer than 100 feet, use hay bales for erosion control and replace them if they become filled with sediment. Prevent water from flowing into landings by appropriately placing water diversions on skid trails and access roads that lead to landings. After logging, smooth the landing, seed, and mulch. The Forest Cutting Practices Act requires that the soil be stabilized and, if necessary, seeded to grass at the end of operations.

4. Erosion Control for Stream Crossings

Avoid stream crossings, but when necessary, locate crossings perpendicular to the stream flow where the stream bottom is solid and the approaches are level for at least 50 feet on both sides of the channel. Temporary poled fords may be used on small streams when skidding small volumes of timber, but they must be removed after 30 days. Bridges should be constructed for crossings that involve large streams, streams with poor bottoms or steep banks, and major skid trails

that will be used for more than 30 days. A reusable temporary skidder bridge can be made of stout timbers and hauled from job to job. Stabilize approaches during and immediately after the operation.

5. Filter Strips

The Forest Cutting Practices Act stipulates that a filter strip of 50 feet must be maintained along the banks of all water bodies, that a maximum of 50 percent of the basal area within the strip can be cut at any one time, and that a period of 3 years must elapse before additional harvesting. Wider filter strips are recommended on steeper slopes or in critical areas. Specifications for filter strip widths are provided in Table 22. Although harvesting is permitted within the filter strip, logs should be winched out of the strip, and disturbance should be minimized. In addition, logging equipment may not be operated on the floor of a filter strip, except at stream crossings or on pre-existing logging roads.

Table 22. Filter Strip Widths (feet)

Slope (percent)	Filter Strip Width	Critical Areas Width
0	50	50
10	50	90
20	65	130
30	85	170
40	105	210
50	125	250
60	145	290
70	165	330
80	185	370
90	205	410
100	225	450

6. Wetlands

The Forest Cutting Practices Act stipulates that a maximum of 50 percent of the basal area of bordering vegetated wetlands can be cut at any one time (in small patches) and that a waiting period of 3 years must be observed before another cut is made. The Act also specifies that wetlands may not be harvested or crossed except when the ground is frozen, dry, or otherwise stable enough to support logging equipment. Avoid or minimize access through wetlands. Where a crossing is essential, rehabilitate existing accessways if it will result in less disturbance than constructing a new accessway.

7. Skid Trail and Landing Seeding

Upon the completion of harvesting activities, disturbed areas should be seeded. A table of possible seed mixtures and their soil pH ranges is provided in the water quality handbook. Recommended seeding times are April 15 to June 15 and August 1 to September 15. Mulching with hay is recommended.

8. Close of Operations

At the close of timber operations, remove temporary bridges, culverts, and fords. Smooth and grade roads and landings, and install appropriate water diversion devices. Revegetate or stabilize disturbed areas as necessary. Restrict access to the harvest site. When finished, notify the appropriate State Service Forester to schedule an inspection, as required by regulation. The Forest Cutting Practices Act requires that all trash, such as cans, papers, discarded tires and metal parts, and other junk be removed.

State Contact:

James W. Soper
Dept. of Environmental Management

MICHIGAN

Reference: Michigan Department of Natural Resources. *Non-point Source Pollution Control on Forested Lands in Michigan - DRAFT.*

BEST MANAGEMENT PRACTICES

1. Roads
2. Timber Harvesting
3. Site Preparation and Reforestation
4. Wildfires

1. Roads

The entire road system should be designed before any road construction begins. Use aerial photographs, topographic maps, and soil surveys in addition to site reconnaissance to plan the road system. Prepare a map of the area to be harvested that displays the proposed locations of roads, landings, and major skid trails.

Where possible, construct roads on side hills for good cross drainage, but avoid seeps, springs, and swampy areas. Road grades should be between 2 and 10 percent, and long steep grades or level grades should be avoided. Grades of up to 15 to 20 percent are acceptable for short distances, but at least 300 feet of road above and below should have less than a 10 percent grade. Plan for the installation of road drainage structures. Locate roads a minimum distance of 50 feet or more from any free-flowing watercourse. Retain adequate buffer strips between roads and perennial and intermittent streams. Buffer strip widths depend on the slope between the road and stream. Minimize soil disturbance in the buffer area.

Roads should follow the contour as much as possible with grades between 2 and 10 percent. Steeper grades, not exceeding 15 percent, are permissible for distances up to 200 feet. On soils with severe erosion hazard, grades should be 8 percent or less, but grades not exceeding 12 percent for 150 feet are acceptable. Provide a minimum width of 10 to 14 feet for single track roads. Cross streams perpendicular to the stream channel and do not impede stream flow. Road gradients approaching water crossings should be changed to disperse water at least 50 feet from the watercourse.

Out-slope the entire width of the road where gradient permits. In-slope the road toward the bank on sharp turns for road gradients 15 percent or greater, and on clay and/or slippery soils. On in-sloped roads, install cross drainage structures 25 feet up-grade on short stretches of road where gradients exceed 10 percent. Broad-based dips can be used on haul roads with gradients less than 12 percent. Use 20-foot-long, 3 percent reverse grade dips. Water bars should be used to divert water from retired haul roads. Spacing tables are provided in the manual for broad-based dips and water bars. Culverts should be installed so both ends extend 2 feet beyond the side slope for stream crossings and 1 foot beyond for road cross drainage. Culverts used as stream crossings should be installed at the same slope as the stream channel; cross drainage culverts should be sloped 2 to 4 percent. Place energy dissipators (e.g., rip-rap, large stones) at cross-drainage culvert outlets.

When operations cease for a period of several years, roads should be retired and exposed soil areas stabilized and revegetated. Smooth and reshape all road and landing surfaces. Remove culverts and replace with water bars or ditches. If culverts are covered by more than 2 feet of fill, then leave them in place and

continue maintenance. Remove all temporary stream crossings, and seed and mulch critical areas near streams.

Locate log landings outside buffer strips. Landings should have a slight slope and should be on well-drained soils. Provide adequate drainage on approach roads and trails so that surface water drainage does not enter the landing area. Service equipment so that oil, fuel, and other lubricants are drained into containers and properly disposed of. Revegetate log landings immediately following completion of operations.

Locate skid trails outside the streamside buffer area. Skid trails should not be steeper than 15 percent, with the exception of short, steep segments that do not exceed 20 percent. Logs should not be skidded through stream channels. When crossing watercourses, use a bridge or culvert of acceptable design placed perpendicular to the stream flow. Water bars should be installed on skid trails upon completion of operations; specifications for installation are provided.

2. Timber Harvesting

Preharvest plans should include a map identifying property boundaries, streams and drainages, soils, slope, critical environmental concerns, main haul road and skid trail locations, log landings, stream or drainage crossings, and buffer strips.

Buffer strips must be maintained along all perennial and intermittent streams, lakes, and ponds. The minimum buffer strip width is 50 feet, with the width increasing by 15 to 20 feet for each slope increase of 10 percent. A table with recommended buffer strip widths is provided in the manual. Leave the forest floor undisturbed in the buffer area. Modify harvesting activities to retain a stable area in the buffer and maintain desired shading of

streams. Locate haul roads, landings, and equipment storage and maintenance sites outside the buffer. Do not operate equipment in the buffer when the soil is saturated. Remove harvested tree limbs and tops from streams.

Provide proper waste receptacles in maintenance areas, and dispose of waste properly. Locate fueling areas away from water bodies at locations where spills can be contained and treated properly. Designate specific areas for lubricant draining, and provide proper collection and storage. Maintenance vehicles should possess equipment to collect and store lubricants drained during repair activities.

3. Site Preparation and Reforestation

Use site preparation techniques that cause minimum soil disturbance. Provide adequate buffer strips around site preparation activities. Avoid operations during periods of saturated soil conditions. Avoid concentrating residues from shearing and raking operations in wetland areas. Locate windrows outside buffers and pile to minimize their interference with natural drainage. Avoid shearing and raking on organic soils except under frozen soil conditions. Limit disking to slopes of less than 10 percent and follow land contours. Patch or row scarification are preferred mechanical site preparation methods for artificial regeneration. Patch or row scarification should follow land contours as long as operator safety is maintained. Drum chopping should be conducted up and down the slope so that the blade depressions are on the contour.

Conduct prescribed burning with trained crews and operate under proper humidity, temperature, and wind conditions. Plan and construct firelines prior to burning, and construct water bars where slopes are greater

than 2 percent. Provide adequate buffer strips if a burn is adjacent to perennial watercourses, and maintain erosion control structures after a burn.

Apply chemicals according to manufacturer's instructions, and dispose of containers and residues properly. Do not apply pesticides when there is danger of drift, when honeybees or other pollinating insects are visiting plants, or in ways that may contaminate water. Do not clean spray equipment or dump excess spray material near bodies of water. Dispose of empty pesticide containers promptly and properly.

4. Wildfires

The loss of vegetative cover from wildfires may leave soil susceptible to erosion. Bare areas adjacent to stream banks should receive the highest priority for revegetation. Firelines should be revegetated and stabilized. Water bars should be installed in fire lines at spacing provided.

State Contact:

Edward E. Eckart
Department of Natural Resources
(517) 335-3351

MINNESOTA

Reference: Minnesota Department of Natural Resources/Division of Forestry, Minnesota Pollution Control Agency, and other organizations. 1989. *Water Quality in Forest Management: Best Management Practices in Minnesota*.

BEST MANAGEMENT PRACTICES

1. Fuel, Lubricant, and Equipment Management
2. Filter Strips
3. Forest Roads
 - a. Design
 - b. Construction
 - c. Maintenance
4. Timber Harvesting
5. Mechanical Site Preparation
6. Pesticide Use
7. Prescribed Burning

1. Fuel, Lubricant, and Equipment Management

Precautions are needed to prevent water contamination when using fuels, lubricants, and other materials associated with heavy equipment operation. Proper equipment maintenance is essential to protecting water resources from petroleum products contamination. Designate specific areas for fueling and draining lubricants from equipment. These locations should be sited where spills can be contained and properly treated, and away from water. Properly store, collect, and dispose of all wastes. Provide maintenance vehicles with the equipment necessary to collect and store lubricants drained during repair activities.

2. Filter Strips

Establish adequate filter strips around perennial and intermittent streams, lakes, and ponds. Forest management activities in filter strips should maintain the integrity of the filter strip and should not expose soils. Filter strip widths vary depending on the slope of the land between the road and stream. Recommended widths are 25 feet for 0-1 percent slopes, 30-50 feet for 2-10 percent slopes, 50-70 feet for 11-20 percent slopes, 70-110 feet for 21-40 percent slopes, and 110-170 feet for 41-70 percent slopes.

3.a. Forest Road Design

The access system should be planned to minimize impacts to water quality. Determine whether existing roads need to be improved or relocated. Minimize the total road mileage, number of stream crossings, and amount of ground disturbance. Locate roads away from watercourses and water bodies, outside filter strips, and above the ordinary high water mark. Design roads to have a slight grade of 1-2 percent, and avoid grades in excess of 10-12 percent. A maximum grade of 5 percent is recommended for erodible soils. Design roads to minimize erosion by providing maximum cross drainage and minimum down-road flow. Spacing for drainage structures is provided.

Permanent stream crossings are recommended when long-term use is expected or when the crossing will be used frequently over the short term. Design culverts and bridges to minimize impacts on water quality, and size them to accommodate the 25- to 50-year flood. Fords should be used only where the subgrade is predominately rock and when water is not expected to be present during any of the road use cycles. Streams should be crossed at a right angle where the approaches are fairly level, the streambed and banks are composed

of firm cohesive soils or rock, and the natural stream channel will be only slightly disturbed by construction. Crossings should not impede fish passage.

For winter roads, consider using culverts or bridges to cross definite drainages where winter roads are to be used for 5 years or more. Temporary crossings must have proper drainage structures so that there will not be an increase in the natural sediment load. Construct winter road crossings on level terrain. Where slopes exceed 3 percent, do not place organic materials in winter crossings, and remove temporary winter crossings prior to breakup.

3.b. Forest Road Construction

During the clearing phase of road construction, do not impede water flow or increase sedimentation of waters through improper location of clearing debris. Shape in-slopes and backslopes to be 1½:1 or flatter to increase stability. Compact roadbed material to reduce water infiltration, to increase the load-bearing capacity, and to minimize the settling of fill material. Use filter materials or other subgrade support in areas of peat or bog to minimize siltation. Evaluate alternatives to road surfacing, but grades with significant erosion potential should be surfaced.

During construction, provide adequate drainage of road grades and subsurface to help stabilize areas where slope instability is encountered. Install dips, water bars, and cross drainage where needed on all temporary roads. Use open-top culverts to remove surface water from temporary or occasional-use roads. Do not drain surface water diverted from roads directly into open water; drain it into a filter strip or a vegetative draw. Install drainage structures on streams as soon as feasible. These drainage structures should accommodate the 25- to 50-year flood.

Stabilize bare soil areas to reduce erosion and install siltation barriers. Install silt fences during construction in sites where roads and water have close contact for long periods.

3.c. Forest Road Maintenance

Clean debris and windfalls from culverts, ditches, dips, and other structures prior to periods of peak flow. Keep traffic off roads during wet periods and spring breakup. Place road barriers and signs when permanently closing roads.

For active roads, fill in ruts and holes that develop during road use. Grade the road surface periodically; minimize berms along the edge of the road. Apply dust control agents in a manner that will minimize entry of these compounds into water. For inactive roads, ensure that the road remains in stable condition by occasionally blading or seeding the surface. Maintain drainage structures and place water bars, where necessary, before roads are abandoned. Water bar spacing recommendations are provided.

4. Timber Harvesting

Timber harvesting activities should follow a plan that incorporates water quality protection into all operations. When developing a plan for timber harvesting, perform an "on-the-ground" evaluation in addition to using aerial photographs, topographic maps, and soil surveys. The plan should consider the location of surface water and wetlands; the location of stream crossings; the number and location of landings, roads, and skid trails; and the compatibility of the timing of harvesting operations with soil, topography, and weather conditions. Limit site disturbance by accomplishing as many management objectives as possible through a single timber harvesting operation. Determine the timber sale size and

duration, and the anticipated season and method of harvest.

Minimize landing size and locate landings on level or gently sloping, stable ground away from low or poorly drained areas, open water wetlands, and filter strips. If possible, avoid locating landings on open water wetlands. Landings may be placed on other wetlands during frozen conditions. Debris from upland landing construction areas should be deposited above the ordinary high water mark. Install erosion control measures as necessary.

Avoid locating skid trails in filter strips and minimize long, straight skid trail stretches. Install bridges, culverts, etc. to prevent repeated soil and streambank disturbance. Drainage specifications can be found in the Forest Roads section.

Conduct harvesting operations in a manner that protects water quality. Avoid felling timber into nonforested wetlands, and prevent logging residue from entering all streams, lakes, and wetlands, except where residue placement is specifically prescribed for fish or wildlife habitat. Winch logs off steep slopes where conventional skidding would result in erosion and sedimentation. Seed, fill in ruts, and install water bars and erosion barriers where appropriate. Restore watercourses to approximate their natural condition, and periodically inspect erosion barriers.

5. Mechanical Site Preparation

Evaluate the potential water quality impacts prior to implementing site preparation operations. Site preparation practices should be related to specific site characteristics, such as soil, topography, vegetation, access, distance to surface waters, and depth to ground water. Minimize site disturbance and provide adequate filter strips. Avoid operations during periods of saturated soil conditions. Manage

vegetation adjacent to designated trout streams to minimize increases in stream temperature. Avoid concentrating residues from shearing and raking operations in wetland areas, and design shearing and raking practices to prevent direct runoff of sediment into water. Locate windrows and piles to minimize interference with natural drainage patterns, and locate windrows outside filter strips. Avoid disking in areas where it will increase direct runoff of sediment into water, and follow land contours. Use patch or row scarification as the preferred site preparation method for artificial regeneration, and follow land contours. Consider alternatives to mechanical site preparation, such as chemical treatments, prescribed burning, and hand scarification when conducting operations on steep slopes or highly erodible soils.

6. Pesticide Use

Planning is the essential first step in reducing pest problems while maintaining water quality. Consider using Integrated Pest Management (IPM) strategies as part of an overall program to control pest problems. When selecting a pesticide, consideration should be given to site factors, pesticide characteristics, application conditions, delivery systems, and application techniques. Choose products suitable for use on target species, and carefully follow all label directions. Employ only licensed pesticide applicators. Pesticides with high affinities for adsorption (K_{oc} values greater than 1,000) are recommended for the following soil characteristics: coarse textures, low organic matter (less than 2 percent), shallow depth to ground water, and poor drainage.

Properly transport, store, mix and load, and apply pesticides. Secure containers properly to prevent movement during transport. Store pesticides in their original containers with labels intact, and at locations that minimize the possibility of impacts on water quality in case

accidents or fires occur. Do not mix pesticides near wells or open surface waters, and use the lowest rate of pesticide possible to achieve the desired level of pest control. Do not fill pesticide mixing or application equipment directly from surface water or a public water supply unless the equipment contains proper and functioning anti-backsiphoning mechanisms. Never apply pesticides directly to water or when there is a likelihood of significant drift, and avoid the use of broadcast application methods within filter strips. Clean equipment where pesticide residues will not enter streams, lakes, or ponds, and clean all mixing and loading equipment thoroughly. Do not clean pesticide application equipment in surface waters. Properly dispose of pesticide wastes and containers in accordance with state laws. Triple rinse all empty plastic and metal pesticides containers, and add rinse water to spray solution. Pesticide characteristic tables are provided.

7. Prescribed Burning

Carefully plan burning according to weather, time of year, soil, topography, and fuel conditions. Use adequately trained and experienced personnel. Locate firelines on the contour and avoid straight uphill-downhill placement. Construct firelines to the minimum depth and width necessary to control the fire. Use natural or in-place fire barriers and establish filter strips. Minimum filter strip widths should be 50 to 100 feet. Maintain erosion control measures, as needed, on firelines. Close water wells excavated for wildfire suppression.

Consider use of a retardant in place of plowed firelines where fireline construction will result in unacceptable erosion. Prevent or minimize runoff of retardant chemicals into water by keeping filter strip areas off-limits to retardant use. Do not clean retardant application

equipment in lakes or streams, and do not allow fuel or oil from pumper units to drain or drip into lakes or streams.

State Contact:

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Other Available State Information

Brochures	<i>Best Management Practices for Water Quality in Urban, Agricultural and Forestry Applications; Water Related Land Use Programs: Shoreland Management, Wild and Scenic Rivers, Floodplain Management</i>
Videos	<i>Best Management Practices in Minnesota Forestry</i>

MISSISSIPPI

Reference: Mississippi Forestry Association, Environmental Affairs Committee. 1989. *Mississippi's Best Management Practices Handbook*.

BEST MANAGEMENT PRACTICES

1. Woodland Access Roads and Trails
2. Site Preparation
3. Tree Planting
4. Forest Harvesting
5. Revegetation of Critical Forest Areas
6. Filter Strips

1. Woodland Access Roads and Trails

Locate roads and trails to serve the intended purpose while facilitating adequate control of surface waters and sedimentation. Avoid hazardous areas and problem soils, and locate roads and trails where side drainage can be attained. Roads, trails, and landings located above a watercourse should have a filter strip between the disturbed area and the stream. Do not locate roads in filter strips.

Avoid flat, no-grade roads, and design road grades to be between 2 and 10 percent. Steep grades above 10 percent can be used for short distances, but there should be at least 300 feet above and below the steep area in which a grade of 10 percent or less is maintained. Avoid long steep grades to reduce the total number of drainage structures needed. Road surfaces should be a minimum width of 10 feet, but wide enough to enhance surface drying during wet periods. Brush and trees should be removed from the right-of-way to a width of 14 to 16 feet.

Construct cut-and-fill slopes at the normal angle of repose, and do not make them steeper than 1:1 unless properly designed retaining walls are used. Vertical banks may be used without retaining walls if the soil is stable and water control structures are adequate. Material from the grubbing or clearing operation can be used to construct brush barriers to filter runoff from disturbed areas.

Install surface water control structures during construction. Use a broad-based drainage ditch as a water catchment and drainage channel. It requires an outslope of approximately 3 percent and a minimum width of 20 feet. Spacing is determined by the following formula:

$$\text{Spacing (feet)} = \frac{400}{\text{slope \%}} + 100$$

Use bridges over larger streams where heavy or long-term traffic is expected. Crossing structures on perennial streams should not impede fish passage. The size of culverts and bridges should be designed on a 5-year, 24-hour frequency storm as a minimum for permanent access roads, and on a 2-year, 24-hour storm frequency for temporary access roads. Tables are provided to determine the required cross-sectional area. Open log culverts are not recommended for permanent roads, but are acceptable on temporary roads. Pipe culverts can be used on permanent access roads. Install erosion protection measures at pipe outfalls. Fords should be used only if streambeds are solid and if the installation of bridges and culverts will accelerate soil movement. Fords should not be used in critical water areas. Out-sloping the entire width of the road toward the fill bank reduces the number of drainage structures and is an effective way to remove excess water if the soil type is suitable.

When planning the skid trail system, locate landing areas first and design skid trails with grades less than 15 percent. Avoid streambeds, rocky places, adverse slopes, and long, steep grades. When crossing streams, construct small bridges or install culverts perpendicular to streamflow.

Upon completion of harvesting operations, remove temporary drainage structures and clean all remaining drainage structures and ditches. Culverts should be maintained or replaced with waterbeds or ditches. Install water bars and scatter slash on skid trails. A recommended water bar spacing table is provided in the manual. Smooth and reshape roads and trails for seeding, and revegetate cuts, fills, ditches, and other disturbed areas. Restrict access with barriers, gates, or other structures.

2. Site Preparation

Prescribed burning can be used before planting or seeding to reduce logging residues and undesirable trees and vegetation. Fire lines should be located on the contour at a grade of less than 10 percent if possible. Grades, ditches, and water bars should be planned and installed when the line is being constructed. A prescribed burn line should never be built down a slope in a shallow natural gully. Leave a filter strip between fire lines and water bodies. Prevent extremely hot burns. If erosion occurs on the burned area, revegetate the area.

Conduct mechanical site preparation to minimize erosion and sedimentation and prevent accumulation of debris in watercourses. Limit the degree of site preparation to the amount necessary to achieve a well-stocked stand of the desired species. Mechanical site preparation should be avoided on steep slopes with extremely erodible soils. The use of drum choppers and disks is

recommended because there is less disturbance of the topsoil and litter than when bulldozing, raking, or blading. Construct windrows on the contour and provide numerous breaks to prevent damming of water behind the windrow. Use filter strips to keep sediment from site-prepared areas out of streams.

Consider the use of chemicals on highly erodible soils. Pesticide use should be carefully planned to prevent contamination of watercourses and damage to aquatic life. Always use pesticides in accordance with label instructions, and adhere to all federal and state policies and regulations governing pesticide use. Choose products that are registered for the intended use. All pesticides should be properly transported and stored. Mix pesticides in locations far away from springs, streams, and lakes to prevent contamination. Apply them when atmospheric conditions will not contribute to atmospheric or water pollution through pesticide drift or volatilization. Never apply pesticides directly to water (except when it is approved). Maintain buffer strips to avoid drifts or accidental direct application of chemicals to water bodies. Table 23 contains recommended buffer widths based on application techniques. Clean equipment away from streams and other water sources. Dispose of excess pesticides and containers in accordance with the manufacturer's label instructions.

Table 23. Recommended Buffer Widths

Application Method	Width (feet)
Aerial	100
Ground Vehicle	50
Hand Spray	25
Hand Dispersion	15

3. Tree Planting

Mechanical tree planting may cause short-term erosion problems. To avoid ditch formation, planting should be conducted along the contour. Hand planting causes little or no erosion.

4. Forest Harvesting

During timber harvesting, skidder logging should be performed along the contour and yarding should be conducted uphill. Minimize the number of trips along the same skid trail. Filter strips should be maintained between heavily cut areas and watercourses. All tops and other logging matter falling into streams must be removed. When servicing equipment, drain all petroleum products and radiator water into containers, and dispose of them according to label instructions.

Locate landings and concentration yards in a manner that minimizes erosion and subsequent siltation problems. Leave adequate filter strips between landings and watercourses. Landings and yards should have a slight slope to ensure good drainage. Provide for adequate drainage on approach roads, and install diversion ditches around the uphill side of landings to prevent drainage water from entering the landing area and causing muddy, wet conditions. Stabilize landings and yards immediately following completion of operations by mulching and/or revegetating.

Portable sawmills should be located on reasonably level sites, and the sawdust piles should be deposited on level ground at least 300 feet from streams.

5. Revegetation of Critical Forest Areas

Road surfaces should be smoothed and shaped to permit the use of conventional equipment for seedbed preparation, seeding, mulch

application, anchoring, and maintenance. To establish vegetation, the suggested fertilizer rate is 400 pounds of 10-10-10 per acre and the suggested application rate of lime is 2 tons per acre. Loosen the top layer of soil, and incorporate lime and fertilizer into the top 3 to 4 inches. Select seeding mixtures adapted to the soil and site conditions. Maximum seeding depth should be $\frac{1}{4}$ inch on clayey soils and $\frac{1}{2}$ inch on sandy soils. When seeding is conducted on highly erodible soils, under adverse soil conditions, or on less-than-optimal seeding dates, mulch material should be applied immediately. Protect the seeding area from grazing, fire, insects, vehicles, traffic, etc. Fertilize plants at one-half the establishment rate when needed to maintain plant vigor. Conduct frequent inspections. SCS guidelines for grass or small grain cover for disturbed sites are provided, as well as instructions on how to calculate seed and fertilizer needs for roads and disturbed areas.

6. Filter Strips

Maintain a filter strip between watercourses and roads, trails, and landings. Runoff from these areas should not be channeled into the strip, but should be dispersed across it. Consider the following factors when determining filter strip width.

- The amount and rate of runoff that will pass through the strip, which are determined by:
 - (1) the use and treatment above the strip;
 - (2) the slope of land above the strip;
 - (3) the length of slope above the strip; and
 - (4) the erodibility of soil above the strip.
- The physical properties of the filter strip itself, which are determined by:
 - (1) the slope of the land in the strip;
 - (2) the type of vegetation in the strip; and
 - (3) the degree of maintenance the strip will receive.

A general guide is included that recommends filter strip widths based on slope and soil erosion hazard rating. Avoid mechanical site preparation, prescribed burning, and the use of chemicals in filter strips. When understory is absent, do not remove more than 50 percent of the overstory.

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Other Available State Information

Manuals/ Books	<i>Mississippi's Best Management Practices for Wetlands; Silvicultural Best Management Practices for MS</i>
Videos	<i>Best Management Practices</i>

MISSOURI

Reference: Missouri Department of Conservation. 1990. *Missouri Watershed Protection Practices: Management Guidelines for Maintaining Forested Watershed to Protect Streams*.

BEST MANAGEMENT PRACTICES

1. Streamside Zones
2. Stream Crossings
3. Access Roads
4. Timber Harvesting
5. Site Preparation
6. Reforestation
7. Prescribed Burning
8. Chemical Treatment (pesticides and fertilizers)

1. Streamside Zones

The streamside management zones are divided into two parts, primary and secondary filter strips. The primary filter strip is a 25-foot-wide area along each side of the watercourse measured from the top of the stream bank to the stream channel. The width of the secondary filter strip depends on the slope of the surrounding land and is added to the width of the primary filter strip. Table 24 presents the filter strip widths recommended to reduce sedimentation of streams.

In primary filter strips, limit cutting to no more than 25 percent of the trees or 20 to 30 square feet of basal area. The use of wheeled or tracked vehicles should be avoided, and timber should be cabled out of primary filter strips. Felled trees and tops should be removed from watercourses. Direct seeding, hand planting, or mechanical planting practices

may be conducted in the primary filter strip. Avoid locating of roads (except at designated stream crossings), log landings, log decks, and portable sawmills in the SMZ. Prescribed burning, use of pesticides, and grazing of animals should be avoided in the primary filter strip.

The recommendations for activities within the secondary filter strip are similar, although less restrictive, than those established for the primary filter strip. Careful use of wheeled or tracked vehicles is permitted within the secondary filter strip. Gully leveling should be avoided unless immediately seeded and mulched.

2. Stream Crossings

Vehicle traffic across streams should be avoided whenever possible. Advance planning will reduce or eliminate the number of stream crossings needed. Install properly sized culverts where permanent roads cross streams. A table is provided in the manual that recommends culvert pipe sizes. Locate fords perpendicular to the stream channel and construct only where the stream bottom is hard and relatively level. All approaches to streams should be made from grades of 3 percent or less. Soil around culverts, bridges, and fords should be stabilized with coarse rock or large stones. Temporary crossings made of logs or brush should be avoided, as well as any practice that alters the stream flow.

3. Access Roads

The location of access roads should be planned in advance to minimize their number and slope. Construction of roads should provide for adequate water drainage from the road. The slope of the road should be kept gradual by constructing the road along the contour. Roads should be located above the floodplain and wet areas. Avoid road construction within

Table 24. Recommended Primary and Secondary Filter Strip Widths

Slope (percent)	Primary filter strip (feet)	Secondary filter Strip (feet)	Total filter strip width (feet)
0	25	0	25
10	25	20	45
20	25	40	65
30	25	60	85
40	25	80	105
50	25	100	125
60	25	120	145

SMZs. Road grades should be kept to 8 percent or less, except where the terrain requires short, steep grades. The roadbed on temporary roads should be 12 to 14 feet wide. Road should be surfaced with gravel where necessary to support heavy equipment and prevent erosion. Remove shade trees from along roadsides to allow for road drying. Cleared debris may be placed on the lower side of fill slopes to prevent erosion. Broad-based dips and water turnouts should be used to divert water from road surfaces. Tables and figures are provided in the manual for the construction and spacing of broad-based dips, water turnouts, and water bars. Temporary access roads should be retired by reshaping, seeding, and mulching, in combination with water bars.

4. Timber Harvesting

Log landings should be located on stable, adequately drained soils and oriented so that skidding is directed away from streams. Disposal of logging debris in streams or water bodies should be avoided. Log landings should be no larger than necessary to handle loading activities. Portable sawmills should be located away from streams or other water bodies. Provisions should be made for the disposal of wastes and garbage.

5. Site Preparation

Avoid mechanical site preparation that exposes the soil on steep slopes. Bulldozing should disturb as little soil as possible. Windrows should be constructed along the contour, with breaks left for fire control. Exposed soils should be seeded with herbaceous vegetation selected to quickly establish ground cover. Filter strips should be left along watercourses to trap sediment.

6. Reforestation

Do not use mechanical seedling planters on steep slopes; plant tree seedlings by hand on steep slopes. Avoid site preparation in SMZs.

7. Prescribed Burning

Prescribed burning should be carefully planned and executed while observing weather conditions. Prior to burning, locate fire breaks along the contour. When fire breaks are at slopes greater than 5 percent, water bars should be used at frequent intervals to slow and disperse water.

8. Chemical Treatment

Use chemicals, dispose of containers, and clean equipment in accordance with the manufacturer's label instructions. Pesticide use should be avoided in the primary filter strip, and only pesticides approved for water use may be applied in secondary filter strips.

State Contact:

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(314) 751-4115

MONTANA

Reference: Logan, B., and B. Clinch. 1991. *Montana Forestry Best Management Practices: Forest Stewardship Guidelines for Water Quality*. Montana Department of State Lands.

BEST MANAGEMENT PRACTICES

1. Roads
2. Streamside Management
3. Timber Harvesting
4. Slash Treatment and Site Preparation
5. Winter Activities
6. Hazardous Substances
7. Stream Crossings

1. Roads

Roads should be properly designed to prevent water quality problems from construction. Use existing roads when practical, unless such roads would cause an erosion hazard. Fit the road to the existing topography by locating the roads on the natural contour. Avoid constructing long, steep roads. Minimize the number of stream crossings, but when crossings are necessary, select stable streambeds. Locate roads a safe distance from streams when the road will run parallel to the stream. (A more detailed discussion is presented in the streamside management section.)

Avoid earth-moving activities when the soils are excessively wet and do not significantly disturb roadside vegetation. Stabilize erodible soils by seeding, compacting, rip-rapping, benching, mulching, or other suitable means prior to fall or spring runoff. Refrain from using woody debris in fill portions of the road

prism, and balance cuts and fills when possible. Pile slash and woody debris in a row parallel to the road on potentially erodible slopes.

Provide adequate drainage from road surfaces by using out-sloped or crowned roads, drainage dips, or in-sloped roads with ditches and cross drains. For in-sloped roads, plan ditch gradients between two and eight percent. Figures are provided for drainage techniques. Cross drains, culverts, water bars, dips, and other drainage structures should not discharge onto erodible soils. Road drainage should be routed through SMZs, filtration fields, or other sediment settling structures. Periodically inspect and maintain erosion control structures. Debris should be cleared from all drainage outlets. Upon completion of silvicultural activities, road surfaces should be crowned, outsloped, insloped, or water barred.

2. Streamside Management

A 50-foot-wide strip on both sides of a stream is the mandated minimum for an SMZ. The 1991 Streamside Management Act prohibits the following activities in SMZs:

- broadcast burning;
- the operation of wheeled or tracked equipment, except on established roads;
- clearcutting;
- road construction, except at stream or wetland crossings;
- the handling, storage, application, or disposal of hazardous or toxic materials in a manner that pollutes streams, lakes, or wetlands or that may cause damage or injury to humans, lands, animals, or plants;

- side-casting of road material into a stream, wetland, or watercourse; and
- depositing slash into streams or other water bodies.

Directionally fell trees away from streams. Suspend the lead end of logs during skidding whenever possible, and use cables to end line logs out of SMZs and wetlands when ground skidding systems are employed. Logs should be fully suspended when skyline skidding across a stream. Consider hand-scalping and planting within the SMZ.

3. Timber Harvesting

Use the logging system that best fits the topography, soil type, and season. Use economically feasible yarding systems that will minimize road densities. Design and locate skid trails and skidding operations to minimize soil disturbances. Limit the size and number of log landings. Avoid landing locations that will require skidding through drainage areas. Divert drainage from landing areas onto stable areas.

Limit the construction of skid trails on erosive lands to a grade of less than 30 percent. Use water bars and grass seeding to minimize erosion on skid trails. Tractor skid when compaction and erosion hazards are low, but avoid tractor or wheeled skidding on wet soils or on slopes exceeding 40 percent, unless the operation can be conducted without causing severe erosion. Upon completion of harvesting activities, install water bars on skid trails, landings, or fire trails. Tables are provided in the manual for spacing water bars.

4. Slash Treatment and Site Preparation

Use brush blades on bulldozers when piling slash; avoid the use of bulldozers with angle blades. Do not overscarify the soil. Site

preparation equipment that produces irregular surfaces is preferred. Low slash and brush should be left to reduce erosion and maintain cover for seedlings. Limit exposure of soils up and down the slope during mechanical scarification.

Properly dispose of logging machinery debris, such as tires and broken cables. Construct water bars in fire lines to prevent excessive erosion. Broadcast burning and/or herbicide treatments are the preferred methods of site preparation, especially on steep slopes. Avoid intense fires unless absolutely necessary to achieve silvicultural objectives. Reforest site prepared areas as soon as possible.

5. Winter Activities

Conduct winter logging activities when the ground is frozen or when snow cover is greater than 1 foot. Before logging, mark existing culvert locations. During and after logging, make sure that all culverts and ditches are functional. Mark all streams prior to snowfall, and conduct activities within SMZs so that ground disturbance is minimized. Before felling in wet unfrozen areas, use tractors or skidders to compact the snow for skid road locations. Avoid steep trails that may be subject to erosion in the spring. Remove all slash and tree tops from streams.

During cold weather, plow snow from roads to allow deep freezing of the road grade prior to hauling. Use compacted snow for roadbeds in roadless, wet, or sensitive areas. Following the completion of snow road use, restore stream crossings to preroad conditions to prevent the formation of ice dams.

6. Hazardous Substances

Comply with regulations governing the storage, handling, application, and disposal of

hazardous substances. Do not transport, handle, store, load, apply, or dispose of hazardous substances or fertilizer in such a manner as to pollute water supplies or waterways, or cause damage or injury to land, including humans, desirable plants, and animals. Do not store, mix, or rinse hazardous substance below the high-water mark of waters. Develop a contingency plan for hazardous substance spills, to include cleanup procedures and notification of the State Water Quality Bureau.

Pesticides must be applied by hand to specific targets within SMZs. A 25-foot buffer must be maintained along surface water when pesticides are applied using ground equipment; a 50-foot buffer around live water must be maintained for aerial applications. Do not aerially apply pesticides to the SMZ. Apply pesticides during appropriate weather conditions to enhance effectiveness and prevent transport into streams.

7. Stream Crossings

Permanent and temporary stream-crossing structures, fords, rip-rapping and other bank stabilizing measures, culvert installation, and skidding through perennial streams are subject to 310 permits provided by the Conservation District Office. Design stream crossings to allow for fish passage and to minimize impacts on stream flow. Cross streams at right angles to the stream channel when possible. Culverts must be at least 15 inches in diameter for permanent stream crossings. Divert road drainage away from the stream crossings and into the SMZ. Time stream crossing installation to protect fisheries and water quality. Figures on culvert installation are provided in the guide.

State Contact:

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Other Available State Information

Manuals/ Books	Montana Department of State Lands, Forestry Division. <i>1989. Best Management Practices for Forestry in Montana.</i>
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NEVADA

References: Chapter 528, Forest Practice and Reforestation (1979); and Nevada State Board of Forestry, *The Proposed Amended Forest Practice Rules*.

BEST MANAGEMENT PRACTICES

1. Silvicultural Methods
 2. Logging Practices
 3. Erosion Control
 4. Logging Roads
 5. Stream and Lake Protection
 6. Hazard Reduction
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1. Silvicultural Methods

Prior to the beginning of timber activities, a Timber Harvest Plan will be completed. The Plan will designate the silvicultural methods to be used and the objectives. The selection of the silvicultural methods should be based on timber stand conditions, topography, land stability, erosion potential, slash treatment, and visual aspects.

Several silvicultural methods are presented. They include the following methods: thinning; selection; shelterwood; seed tree; clearcutting; and sanitation salvage. The details of these methods are provided in the regulations.

2. Logging Practices

Logging practices must be conducted in a manner that prevents unnecessary damage to residual trees, reproduction, riparian area, and water quality. Landings must be kept to a minimum size and number consistent with safe and efficient logging practices. Landings may be no larger than one-half acre in size unless

otherwise explained in the Timber Harvest Plan. Landings must not be placed within a stream and lake protection zone or in meadows or wet areas.

Tractor yarding equipment may not be operated on known, potential, or active slide areas unless protection measures are provided in the Plan. Timber harvesting may not be conducted under ground moisture conditions that could result in unreasonable soil compaction or erosion. Tractor logging may not be conducted on slopes in excess of 50 percent with a high erosion potential. Cable yarding must be installed, hung, and operated so as to minimize damage to residual timber and production.

In Special Treatment Areas and within 200 feet of public roads, refuse, litter, trash, and debris associated with timber operations must be disposed of in accordance with state, local, and federal laws. Timber operations may not be conducted in a way that allows grease, oil, or fuel to pass into lakes or streams during or after operations.

3. Erosion Control

Following the use of tractor roads, skid trails, landings, temporary logging roads, and fire breaks, water breaks must be installed, natural watercourses must be opened where permanent culverts and bridges have not been installed, and seeding or other practical measures must be taken to prevent soil erosion. Water breaks must be installed based on slope and erosion potential. The specifications for distances between water breaks are provided in Table 25. Water breaks must be constructed so that water is discharged to adjacent areas. Grass seeding should be supplemental to other soil stabilizing measures. Grazing should be excluded from areas where erosion control work has been performed.

Table 25. Maximum Distances between Water Breaks

Erosion Potential	Land Slope (percent)			
	10 or less	11-25	26-50	over 50
Low	300	200	150	100
Medium	200	150	100	75
High	150	100	75	50
Extreme	100	75	50	25

4. Logging Roads

Logging roads should be constructed along the contour of the land to the fullest extent practical. Roads should be constructed to single-lane width with turnouts at reasonable intervals. Turnouts should be no wider than necessary to allow safe passage of logging trucks and equipment. Logging roads should not exceed grades of 15 percent; grades of up to 20 percent not exceeding 500 feet are also permissible. Special drainage provisions must be made on all logging roads regardless of grade. Logging roads must be constructed with no overhanging banks. Any tree with more than 40 percent of its root system exposed should be felled. Locate bridges to avoid displacement of the stream channel. Where the stream channel is changed, rip-rap should be used to prevent erosion. Culvert outflow should be directed to energy-dissipating materials.

Upon completion of harvesting, remove berms from logging roads, except on fills and where necessary to deflect water to drainage facilities. Significant amounts of woody debris should not be used as fill material. Cross-ditches may also be used to supplement out-sloping and other built-in drainages such as culverts, grade breaks, and dips. Figures and tables for drainage structures are provided.

5. Stream and Lake Protection

During timber-harvesting activities, slash, debris, side cast, and other materials must be kept out of the stream and lake transition line. Accidental deposits must be removed as soon as practical. Trees cut within 50 feet of the ground must be felled away from streams. A prepared crossing must be used if logging skid trails must cross a live stream. Install suitable structures to allow for undisturbed stream flow and fish passage. All temporary stream-crossing structures that are not designed for normal maximum stream flow must be removed prior to normal maximum stream flow. All temporary stream-crossing structures must be removed upon completion of logging operations.

Within the stream or lake protection zone, enough trees or shrubs must be retained to provide 50 percent or more of the preharvest shade-producing canopy. A lesser percentage may be left when the rationale is explained and justified in the Timber Harvest Plan. Areas exceeding 800 square feet in size within the stream and lake protection zone, where bare soil is exposed due to timber operations, must be treated to keep soil from entering the stream or lake.

6. Hazard Reduction

Slash may be broadcast burned, but broadcast burning is not permitted within the stream and lake protection zone.

NEW HAMPSHIRE

Reference: Cullen, J.B. *Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire Resource Manual*. New Hampshire Department of Resources and Economic Development, Division of Forests and Lands.

BEST MANAGEMENT PRACTICES

1. Planning
2. Truck Haul Roads
3. Skid Trails
4. Log Landings
5. Erosion Control Devices
7. Stream Crossings
8. Final Stabilization of Haul Roads, Skid Trails, and Log Landings

1. Planning

Use topographic maps, soil surveys, aerial photographs, and site reconnaissance to develop maps for the proposed harvesting units. These maps should identify the location of property lines, watercourses, water bodies, wetlands, steep slopes, landings, truck haul roads, skid trails, stream crossings, and erosion control devices. A well-planned and efficiently designed transportation system will minimize soil disturbance and erosion potential. Construction and harvest operations should be timed to take advantage of seasonal conditions. Develop a plan to provide for the retirement of truck haul roads, skid trails, and log landings.

2. Truck Haul Roads

Locate roads on high ground, following the contour at grades less than or equal to

10 percent. Grades between 3 and 5 percent being the most desirable, but steeper grades are permissible for short distances. The minimum tread width is 10 feet for one-way traffic and 15 feet for two-way traffic. Increase the tread width a minimum of 4 feet for trailer traffic. Minimize the road length between public highways and landings. Avoid excessive cuts and fills, and construct cut-and-fill slopes at or less than the normal angle of repose. When constructing roads on poorly drained soils, use a construction fabric underlayment.

Install water diversion and control structures to provide drainage for the road surface. All devices should discharge runoff onto undisturbed forest floor. When watercourses must be crossed, use the most direct route and cross perpendicular to the stream flow. Divert water from approach roads and discharge it away from the watercourse.

Surface the road with gravel or crushed rock if needed to prevent rutting and erosion. Place gravel or wood chips where the logging road enters a public highway to prevent mud from getting on the highway. Restrict traffic during heavy rains and wet seasons.

3. Skid Trails

Skid trails should be located to take advantage of natural cross drainage and away from watercourses, water bodies, and wetlands. Trail grades should be 15 percent or less, but steeper grades are permissible for short distances. Install water diversion structures to move surface water quickly off trail surfaces and onto undisturbed forest floor. Do not skid logs or drive equipment through streams. When watercourses must be crossed, use the most direct route and cross perpendicular to stream flow. Divert water from the trail approach and discharge it away from the

watercourse. Where feasible, skid across the slope and uphill to landing areas.

4. Log Landings

Locate landings outside filter strips and at least 100 feet from streams, ponds, lakes, and wetlands. If the 100-foot setback is not possible, use sediment traps to minimize sedimentation. Locate landings away from low or poorly drained areas and minimize their size. Provide adequate drainage on approach trails and divert water from landings. When servicing equipment, properly contain and dispose of all petroleum products and other wastes.

5. Erosion Control Devices

Retain filter strips between watercourses and truck roads, skid trails, or log landings. Limit equipment and harvesting operations in filter strips to prevent exposure of mineral soil. Filter strips should be at least 50 feet wide, with an incremental increase of 20 feet for each 10 percent increase in slope.

Use broad-based dips to provide cross drainage for truck roads and heavily used skid trails having a gradient of 10 percent or less. Proper construction requires an experienced bulldozer operator. Specifications for construction and spacing are provided in the manual. On grades steeper than 8 percent, surface dips with stone or gravel. Dissipate runoff water from outlet discharge areas with stone, grass sod, litter cover, slash, or logs.

Water bars can be used on truck roads or skid trails where surface water runoff may cause erosion. Construct water bars at a 30 to 40 degree angle to the truck road or skid trail, and drain them at a 3 percent out-slope onto undisturbed litter or vegetation. Specifications for construction and spacing are provided in the manual. Dissipate runoff water from outlet

discharge areas with stone, grass sod, litter cover, slash, or logs.

Reverse grades are commonly applied to skid trails and are often used in conjunction with other water control measures. Do not use reverse grades on very steep terrain and hardpan soils.

Install cross-drainage culverts where heavy road use is anticipated during and after harvesting. Culvert size should be based on the size of the drainage area and should be able to accommodate periods of high flow. However, culverts should be a minimum of 12 inches in diameter and 20 feet long. Culverts should be spaced according to road grade: 300 feet for 1 to 2 percent slopes, 150 feet for 3 to 10 percent slopes, and 100 feet or less for slopes greater than 10 percent. Install culverts at a 30 to 35 degree angle downgrade, and slope at least 5 inches for every 10 feet of length to permit self-cleaning.

Open-top culverts can be used as a substitute for pipe culverts on smaller operations. Never use open-top culverts to cross perennial or intermittent streams. Specifications for construction and spacing are provided. Routine removal of debris and sediment from these culverts is required to maintain their functionality.

In-sloping should be used when soils are easily saturated or highly erodible. Crowning can also be used in these areas if adjacent land is relatively level with the road bed or the road is on steep side hills. Out-sloping should be used when the area is entirely rock, or when water can be diverted onto undisturbed forest floor.

Corduroys should be constructed on wet soils subject to rutting and extreme compaction. Place 8- to 10-inch diameter poles across the wet area, perpendicular to travel direction, to serve as a road bed. Use geo-textile fabric or

other appropriate bedding if needed. Inspect regularly and repair as needed.

7. Stream Crossings

When watercourses must be crossed, use the most direct route and cross perpendicular to stream flow. Construct stream crossings during periods of low flow, and avoid construction during the egg incubation period of valuable fisheries.

Use temporary bridges on single-lane haul roads or skid trails. It is recommended that a structural engineer be contacted to determine the size and number of stringers required to accommodate anticipated traffic load. Place bridges where stream banks are firm and stable and reasonably level for 50 feet on either side of the crossing. The minimum bridge width should be 10 feet. Bridges must be anchored to prevent washout during periods of high flow. Remove all bridges from truck haul roads and skid trails that will not be maintained.

Fords can be used on streams draining less than 1 square mile, and are permissible only where bridges or pipe culverts are not feasible. Fords are prohibited within 2,000 feet of reservoirs for public and private water supplies or intakes for drinking water. Fords should be constructed on firm, stable streambeds where the stream banks are fairly level for 50 feet on each side of the watercourse. Specifications for construction of stone fords are provided in the manual. Do not cross fords when overtopped with water, and repair and maintain the ford after overtopping. Skidding across stone fords is prohibited.

Install culverts perpendicular to stream flow during periods of low flow on banks that are firm and reasonably level for 50 feet on each side of the watercourse. Culverts should be

placed in the natural channel with no fill underneath. The minimum culvert grade is 2 to 4 percent. Culvert size should be based on the size of the drainage area and should be able to accommodate periods of high flow. Specifications for culvert construction and determining proper size are provided in the manual. Protect both ends of the culvert from erosion.

8. Final Stabilization of Haul Roads, Skid Trails, and Log Landings

Stabilize roads, trails, and landings by regrading surfaces, removing temporary stream and wetland crossing structures, installing water diversion structures, and establishing vegetation on critical areas. Prepare the seedbed by grading, removing debris, and scarifying soil to minimum depth of 3 inches. Lime and fertilize the seedbed according to its needs as determined by a soil test. Lime to pH 6.0 and fertilize at the minimum rate of 500 pounds of 10-10-10 per acre. Seeding mixture tables are provided in the manual. Restrict access to all stabilized areas.

State Contact:

J.B. Cullen
(603) 271-3456

NEW JERSEY

Reference: New Jersey Bureau of Forestry.
*Best Management Practices for New Jersey
Silviculture as They Relate to Water Quality.*

BEST MANAGEMENT PRACTICES

1. Improved Harvesting
2. Seeding and Planting
3. Prescribed Burning
4. Biological and Chemical Insect Control
5. Protection from Livestock

1. Improved Harvesting

Locate roads and skid trails away from wet and poorly drained areas and away from tops and toes of banks and slopes. Retain a buffer strip between roads and water bodies that has a minimum width of 100 feet on slopes less than 30 percent and 150 feet on steeper slopes. When slopes exceed 10 percent, provide drainage structures to divert running water off roads and primary skid trails and discharge the runoff away from streams.

Minimize the number of stream crossings through careful planning. Locate stream crossings where the stream banks are stable, the stream bottom is firm, and the approaches are fairly level. Use the most direct route to cross streams and avoid crossing at bends or through pools. Use temporary culverts, bridges, or runways where stream bottoms or banks would otherwise be damaged, and remove them after use.

Locate landings on gently sloping ground that will provide good drainage, and avoid low or poorly drained areas. Landings should be

located at least 200 feet from streams, ponds, lakes, and marshes.

Plan carefully for the protection of slopes exceeding 30 percent. Minimize the number of skid trails and the amount of skidder traffic, and winch logs off steep slopes whenever possible. Harvest steep slopes during dry weather or when the ground is frozen and snow-covered.

Protect stream banks by controlling skidding and felling that occurs close to watercourses. Design clearcuts to retain a buffer strip along both sides of flowing streams, ponds, and marshes. Cut selectively in this strip, avoiding trees that contribute to maintenance of bank integrity or that provide shade to the watercourse. Directionally fell trees so the tops land away from streams. Do not skid in perennial or intermittent streams or along stream banks. Winch off any logs that lie close to the bank.

Upon completion of harvesting operations, stabilize landings and access roads. Regrade the surface of landings and access roads so they are smooth, level, and free of ruts. Regrade and clean ditches along roadsides, and install water diversion devices as necessary. Close temporary roads. Where necessary, seed access roads, landings, and ditches. Properly dispose of all trash, including oil cans, lunch wrappers, and broken cable.

2. Seeding and Planting

Site preparation can be achieved by machine, fire, and/or chemicals, but must be planned and implemented by skilled professionals. Establish a vegetative cover crop on erodible areas that were cultivated in the fall but will not be planted until spring. Stabilize steep slopes prior to planting. Use herbicides in accordance with the manufacturer's label and established state and federal regulations.

3. Prescribed Burning

Have a plan prepared by a forester, and execute the plan with a trained crew. Do not burn on slopes exceeding 25 percent unless special precautions are taken.

4. Biological and Chemical Insect Control

Evaluate alternatives to chemical control, but protect high-value crops. Plans should be prepared by trained personnel, and chemical application must be made by certified applicators in strict observance with the label and established regulations. Do not spray over water. Use insecticides with short residue times when possible.

5. Protection from Livestock

Woodlots should be fenced to prevent livestock grazing.

State Contact:

George H. Pierson, Chief
Bureau of Forest Management
(609) 292-2520

NEW MEXICO

References: New Mexico Natural Resources Department, Forestry Division. 1983. *Water Quality Protection Guidelines for Forestry Operations in New Mexico*; and Regulations and Laws Related to Forest Management as Adopted December 19, 1989.

The law requires that a harvest permit be obtained from the Division prior to commencing any harvesting operation. The following information is required when applying for a permit:

- the name(s) of legal owner and a description of the land on which the harvest will occur;
- the name and mailing address of the timber purchaser;
- the names and mailing addresses of individuals intended to directly manage harvest activities;
- the cutting unit(s) to be established and all main haul roads established or proposed within the area to be harvested shown on a USGS topographic map of no smaller scale than 1:62500;
- the time schedule for harvesting;
- a forest regeneration plan; and
- a plan for method of harvest and treatment of skid trails and slash on excessive slopes

BEST MANAGEMENT PRACTICES

1. Roads
2. Timber Harvesting
3. Slash Disposal and Site Preparation
4. Chemical Application
5. Reforestation and Timber Stand Improvement

1. Roads

Design road layout prior to the construction, taking into consideration variables such as site and equipment. Design and construct roads to take advantage of the existing landscape. Use natural road building locations away from streams such as benches, ridge tops, and the toe of slopes. Design the minimum road width by reviewing the specifications of the timber projects. Upgrade existing roads when possible. Avoid problem areas such as flood zones, narrow canyon bottoms, wet areas, and highly erodible and unstable soils. Do not locate roads on slopes greater than 60 percent. Table 26 provides the suggested buffer widths of undisturbed soil and vegetation between roads and streams.

Table 26. Buffer Strip Widths

Slope of land (percent)	Buffer strip width (feet)
0	50
10	70
20	90
30	110
40	130
50	160
60	180
70	200

Keep the road grade to a minimum, usually less than 10 percent except for short distances. Prevent the concentration of water on the road by designing adequate drainage features, such as drainage and grade dips, open-top culverts, and cross drains. Figures and specifications are provided for these drainage structures. Drainage can also be achieved by crowning, in-sloping, or out-sloping the road surface. Crown roads located on ridge tops and fairly level land. On moderate slopes, out-slope roads to $\frac{1}{4}$ to $\frac{1}{2}$ inch per foot width. Do not out-slope roads on steep slopes or unstable soils; in-slope these roads and install cross drains. Dissipate discharge from drainage structures with rocks, slash, vegetation, or other materials.

Cross streams perpendicular to stream flow on stable, straight portions of the stream where the approaches are fairly level. Divert road drainage away from all stream crossings. Culvert diameters should be large enough to handle the flows expected from a 25-year storm. Culvert ends should extend at least 1 foot past the fill on both ends. Align the culvert exactly with the stream, on the existing grade, and at the depth of the streambed. Culverts should be inspected frequently and cleared of sediment and debris. Fords should be located only on a stable, rocky portion of the stream.

Road construction activities should be timed to avoid heavy seasonal rains. Balance cut-and-fill materials as much as possible, and do not use woody debris for fill material. Place slash at the bottom of fill slopes to trap sediment and slow runoff. Seed all cut-and-fill slopes with appropriate grass species to prevent runoff and erosion. Remove debris from streams that was added during road construction. Deposit surplus soil and rock in an area where runoff will not threaten streams. Conduct servicing and refueling of equipment well away from streams.

Inspect newly constructed roads after the first heavy rain to ensure that all drainage structures and erosion controls are functioning properly. Prohibit or restrict the use of roads during wet periods, depending on the stability of the road surface. Maintain the proper in-slope, out-slope, or crown, and reshape grade dips.

Remove stream-crossing structures on roads that will be permanently closed. Out-slope closed roads to at least 5 percent to establish natural drainage. Construct water bars to divert runoff. A figure and table are provided in the manual for water bar construction. Prevent unauthorized access to closed roads by means of gates, large water bars, rocks, logs, or slash.

2. Timber Harvesting

Leave a buffer strip of undisturbed vegetation on both sides of streams, following the recommendations provided in Table 26. Remove logging debris added to stream channels as soon as possible. Do not fell trees toward streams if possible.

Plan skid trails in advance of logging operations, taking into consideration the road system, landing areas, topography, and sensitive environments. Do not drag skidder blade during descent. Delay skidding operations during very wet conditions. Avoid skidding in or near perennial or intermittent streams. Raise the lead edge of the logs when skidding. Install water bars on skid trails upon completion of logging activities.

Plan landings in conjunction with the road and skid trail system; locate them on firm, dry ground away from streams. Construct landings no larger than necessary and provide adequate drainage. After completion of harvesting operations, rip, seed, and water bar landings.

3. Slash Disposal and Site Preparation

Before conducting a prescribed burn, prepare a plan with professional forestry assistance. The plan should consider weather conditions and the objective of the burn. Leave a buffer strip of unburned slash next to all streams.

Construct water bars at appropriate spacing along firelines. When drum chopping, disking, or windrowing, equipment should be operated following the contour of the land. Operations should be suspended under very wet conditions.

4. Chemical Application

Avoid direct application of chemicals into water bodies. Maintain adequate buffer strips. Mixing and loading of chemicals should take place away from water bodies. Aerial application of chemicals should be halted when wind speeds reach 5 miles per hour. Chemical applications should be postponed if heavy rains are forecast. All chemical applications must conform to the requirements of the New Mexico Pesticide Control Act. The chemical manufacturer's label requirements should be strictly adhered to.

5. Reforestation and Timber Stand Improvement

Revegetation of all exposed soil should occur after the completion of all operations. State Forestry Regulations require that a regeneration plan must be submitted for all timber harvests greater than 25 acres.

State Contact:

Garrett Blackwell
Forestry and Resource Conservation
Division
(505) 827-5830

Other Available State Information

Manuals/ Books	<i>New Mexico Forest Practices Guidelines; Reducing Erosion from Unpaved Rural Roads in New Mexico</i>
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NEW YORK

Reference: New York State Department of Environmental Conservation. 1981. *A Clean Harvest: Protecting Water Quality During Timber Harvests*.

BEST MANAGEMENT PRACTICES

1. Streams and Water
2. Roads and Skid Trails

1. Streams and Water

Carefully plan stream crossings to minimize erosion and sedimentation. Minimize the number of stream crossings and locate them where the stream banks are stable, the stream bottom is firm, and the approaches are fairly level. Use the most direct route to cross streams and avoid crossing at bends or through pools. Use temporary culverts, bridges, or runways where stream bottoms or banks would otherwise be damaged and remove them after use. Adhere to New York's Water Resources Law and all state regulations when crossing classified streams or logging along wild, scenic, and recreational rivers.

Protect stream banks by controlling skidding and felling that occur close to watercourses. Avoid cutting trees that contribute to maintenance of bank integrity or that provide shade to the watercourse. Design clearcuts to retain a 50-foot wide uncut buffer strip along both sides of flowing streams, ponds, and marshes. Directionally fell trees so the tops land away from streams. Do not skid in perennial or intermittent streams or along stream banks. Winch off any logs that lie close to the bank. Remove all logging debris that accidentally enters watercourses.

2. Roads and Skid Trails

Locate roads and skid trails away from wet and poorly drained areas, and from tops and toes of banks and slopes. Retain a buffer strip between roads and water bodies that has a minimum width of 100 feet on slopes less than 30 percent and 150 feet on steeper slopes. When slopes exceed 10 percent, provide drainage structures to divert running water off roads and primary skid trails and discharge the runoff away from streams.

Locate landings on gently sloping ground that will provide good drainage, and avoid low or poorly drained areas. Landings should be located at least 200 feet from streams, ponds, lakes, and marshes.

Plan carefully for the protection of slopes exceeding 30 percent. Minimize the number of skid trails and the amount of skidder traffic, and winch logs off steep slopes whenever possible. Harvest steep slopes during dry weather or when the ground is frozen and snow-covered.

Upon completion of harvesting operations, stabilize landings and access roads. Regrade the surface of landings and access roads so they are smooth, level, and free of ruts. Regrade and clean ditches along roadsides, and install water diversion devices as necessary. Where necessary, seed access roads, landings, and ditches.

State Contact:

Bart Zek
Division of Lands and Forests
(518) 457-7431

Other Available State Information

Brochures *Timber Harvesting Guidelines
for New York; New York State
Cooperating Timber Harvester
Program*

NORTH CAROLINA

Reference: North Carolina Department of Environment, Health and Natural Resources, Division of Forest Resources. 1989. *Forestry Best Management Practices Manual*; and the Forest Practices Guidelines Related to Water Quality (15NCAC 11.0101-.0209).

The Sedimentation Pollution Control Act requires that an erosion and sediment control plan be submitted and approved for earth-disturbing activities greater than one contiguous acre. Forestry operations are exempt from the Act, providing that forest owners and operators adhere to the performance standards established by the Forest Practices Guidelines Related to Water Quality (15NCAC 11.0101-.0209). The best management practices recommended in the manual can be used to achieve compliance of the performance standards.

FOREST PRACTICES GUIDELINES PERFORMANCE STANDARDS

Streamside Management Zone. SMZs must be established along intermittent and perennial streams and perennial water bodies. The SMZs must have sufficient width and adequate ground cover to confine visible sediment. Locate roads, trails, decks, and mill sites outside SMZs.

Prohibition of Debris Entering Streams. Prevent debris of all types from entering intermittent and perennial streams and water bodies since debris may result in stream obstruction, impediment of stream flow, or water quality degradation. Remove debris that accidentally enters streams.

Access Road and Skid Trail Stream Crossings. Avoid crossing streams when possible. Do not use stream channels as roads

or trails. Construct crossings to minimize sediment entering streams, and to not impede or obstruct stream flow. Protect stream banks and channels from damage. Provide water control devices and/or structures and, within 10 working days of initial disturbance, provide ground cover sufficient to restrain accelerated erosion and prevent stream sedimentation.

Access Road Entrance. Prevent soil and debris from being deposited on public highways, which may result in stream sedimentation.

Prohibition of Waste Entering Streams, Waterbodies, and Groundwater. Prevent oil, fuels, fertilizers, and other chemical waste from entering streams, water bodies, and groundwater.

Pesticide Application. Application must follow the manufacturer's labeling and North Carolina Pesticide Board rules. The term *pesticides* includes insecticides, fungicides, herbicides, and rodenticides.

Fertilizer Application. Apply in a manner that prevents adverse impacts on water quality.

Stream Temperature. Retain sufficient shade on natural perennial streams to prevent temperature fluctuations.

Rehabilitation of Project Site. Within 30 working days after ceasing operations, provide sedimentation control measures to prevent stream water quality damage. Maintain sediment control measures until the site is permanently stabilized. Permanently stabilize SMZ areas and other areas that may directly contribute visible sediment to streams.

BEST MANAGEMENT PRACTICES

1. General Erosion Control
2. Preharvest Planning
3. Streamside Management Zone
4. Access Roads
5. Log Decks, Landings, and Portable Sawmill Locations
6. Skid Trails
7. Stream Crossings
8. Road Drainage
9. Site Preparation and Reforestation
10. Revegetating Disturbed Areas
11. Wildfire Protection

1. General Erosion Control

Minimize the area and degree of soil disturbance that reduces infiltration capacity and destroys protective forest floor and ground cover vegetation. Minimize disturbance to ephemeral stream systems. Minimize changes to the microtopography that result in channelization of large volumes of high-velocity water on bare soil. Provide for dispersal of sediment-laden surface flow into

undisturbed forest floor that has high infiltration capacity. Maximize the distance between large areas of bare soil, and do not operate during soil-saturated conditions.

2. Preharvest Planning

Develop a written preharvest plan to determine which BMPs are necessary to protect water quality and how those BMPs will be implemented. Depending on the site and the nature of the harvest, the plan should address the following: property boundaries; harvest areas; forest type; soil types; slopes; approximate location of haul roads, skid trails, potential log landings, and portable sawmills; watercourses; planned stream crossings; SMZs; and timing of the harvest.

3. Streamside Management Zone

Establish an SMZ along each intermittent and perennial stream and perennial water body. The SMZ must have sufficient width to prevent sedimentation of the watercourse. The width may vary depending on the type of stream, the primary use of the water resource, and the topography. The recommended minimum widths are in Table 27.

Table 27. Recommended Minimum SMZ Widths

Type of Stream or Waterbody	Percent Slope of Adjacent Lands				
	0-5	6-10	11-20	21-45	46+
	SMZ Width Each Side (feet)				
Intermittent	50	50	50	50	50
Perennial	50	50	50	50	50
Perennial Trout Waters	50	66	75	100	125
Public Water Supplies (Streams and Reservoirs)	50	100	150	150	200

In SMZs, limited harvesting is permissible, but the forest floor and ground cover vegetation must remain essentially undisturbed. A maximum of 20 percent evenly distributed bare ground is allowable in SMZs along perennial streams, and a maximum of 40 percent evenly distributed bare ground is allowable along intermittent streams. If the limit is exceeded, ground cover must be provided. Skidders should not operate in ephemeral drainages. Retain a minimum of 75 percent of the pre-harvest shade on the stream channel. Remove all harvesting debris from watercourses.

Do not allow high-intensity broadcast burns in SMZs. Do not allow broadcast applications of fertilizers or pesticides to directly enter or drift into watercourses and water bodies. Do not broadcast chemicals to the surface of ephemeral drainages within the SMZ. Individual stem treatment with herbicides is allowed within SMZs. Locate sawmill sites and landings outside SMZs. Do not locate roads and trails in SMZs, except for stream crossings. Promptly revegetate or provide adequate ground cover for bare soil areas within an SMZ.

4. Access Roads

Preharvest planning is essential for proper road location. If possible, haul roads should be built at least a year before harvest begins so that they have time to stabilize. Locate roads on side slopes, and avoid wet floodplain soils and SMZs. Roads should follow the contour at grades between 1 and 10 percent. Steeper gradients are permissible for short distances, usually not exceeding 200 feet. The application of crushed stone on steep grades can help stabilize road surfaces.

Establish good drainage with properly constructed and spaced ditch turnouts, broad-based dips, culverts, and bridges. Where conditions allow, out-slope the entire width of

the road. Below cross drain outlets, install erosion protection devices. Stream-crossing structures should be sized and installed in a manner that does not impede stream flow or fish passage. Cross streams perpendicular to stream flow. Provide water control measures on approaches to stream crossings.

Vertical road bank cuts in erodible material should normally not exceed 5 feet in height. Road bank cuts more than 5 feet high should be at least a 2:1 ratio, and a ground cover should be provided to control erosion. Use cleared materials for brush barriers along road fills or other erosive areas.

Roads should be inspected at frequent intervals to ensure proper maintenance. Roads should be kept free of obstructions, ruts, and logging debris. When the depth of ruts exceed 6 inches for a distance of 50 feet or greater, regrade the road. Maintain drainage systems during operations. Restrict traffic on roads during unfavorable soil and road surface conditions. Upon completion of operations, shape and smooth the road surface, ensure that drainage systems are functioning, and provide ground cover on steep slopes and all bare soil areas located within SMZs. Control traffic to reduce erosion, sedimentation, and maintenance problems.

5. Log Decks, Landings, and Portable Sawmill Locations

Locate sites for decks and portable mills prior to road construction. Locate decks outside SMZs and on sloping sites to provide good drainage. On steep terrain, locate decks high on the slope to allow skid trails to disperse downhill rather than concentrate at one point. On very long slopes, use mid-slope decks. Prevent water from entering the landing by providing good drainage on approach roads and trails and constructing a diversion ditch around the uphill side of the landing. Remove

and properly dispose of garbage, trash, and wastes from servicing equipment. Do not locate residue piles in ephemeral drainages. During ongoing operations, inspect sites frequently for water quality problems and correct any unacceptable conditions. Upon completion of operations, provide ground cover on decks, landings, and portable sawmill sites.

6. Skid Trails

Avoid construction and use of skid trails that create large areas of compacted bare ground with reduced infiltration capacity. If it is not possible to limit areas of bare ground to acceptable levels using conventional ground skidding, then alternative types of logging systems, such as high-lead and boom cable, should be considered. A recommended sequence of cutting and skidding is to harvest the furthestmost timber first. As harvesting progresses, place logging slash along bare ground areas and leave tree tops in trails. Skid timber in an uphill direction. Downhill skidding should be confined to low gradients and up-slope positions. Skid trails should follow the contour and not exceed grades of 25 percent. Create a zig-zag pattern that avoids long, steep grades. Concentrate skidding on a few primary skid trails. Secondary skid trails should be used no more than two times. Locate skid trails outside SMZs and natural drainages. Do not skid during saturated soil conditions.

Immediately following use, construct high water bars on skid trails to prevent access. On steep slopes and in SMZs, provide ground cover on skid trails and revegetate trails or cover with logging slash.

7. Stream Crossings

Install pipe culverts of adequate type and proper size and length on the natural stream

bottom at a 2 to 4 percent grade. A table is provided in the manual for determining culvert size based on drainage basin area, slope, and soil porosity. Where watersheds require culverts larger than 48 inches in diameter, the use of bridges or multiple culverts is recommended. Select installation sites that do not have sharp bends, have good water entrance and exit areas, and have favorable bank conditions. Use bridges to cross streams that drain large watersheds where culverts can not handle the stream flow, and select the proper type, size, and material to accommodate the maximum stream flow. Protect stream channel and banks from erosion during construction. Fords can be used where the stream system has an existing or applied firm base, but they should be fortified using rip-rap stone or a layer of poles, which should be removed after use. Provide proper surface drainage on road and trail approaches, and discharge runoff into undisturbed areas. Stabilize the crossing area and approach roads.

Routine maintenance of stream crossing structures is important to retain functionality and safe conditions. Inspect for failure and/or effectiveness of approaches, drainage system, fill depth over culvert, flow through structures, bridge decking, abutments and headwalls, emergency spillway (where applicable), and ground cover. Promptly correct conditions or situations that are unsafe or ineffective. Remove culverts and bridges from temporary crossings upon completion of operations, and stabilize as needed.

8. Road Drainage

Water turnouts should be installed as needed, but should be frequent enough to provide good drainage and maximum roadbed drying. Turnouts should not empty directly into adjacent drainages, and runoff water should be dispersed, retained, or filtered at the turnout outlet. Turnouts should be out-sloped 1 to 3

percent and intersect the ditch line at the same depth.

Broad-based dips can be used to effectively collect and divert surface runoff on roads having a gradient of 12 percent or less. They should not be used for cross draining in-side ditches, spring seeps, or streams.

Specifications for construction and spacing are provided in the manual. Install an energy absorber at the dip outlet to minimize erosion. The dip and reverse grade section may require bedding with 3-inch crushed stone to stabilize the surface and prevent rutting.

Rolling dips can also be used as cross drains, but only on primary skid trails having steep gradients. They should not be used for cross draining spring seeps or streams.

Specifications for construction and spacing are provided in the manual. Install an energy absorber at the dip outlet to minimize erosion.

Pipe culverts are usually installed as cross drains only on permanent roads. Culverts should be sized to site conditions, but should be a minimum of 14 inches in diameter. Place the culvert on a 2 to 4 percent grade, skewed 30 percent downgrade. Both ends of the culvert should extend beyond the toe of the fill slopes. Install an energy absorber at the culvert outlet to minimize erosion.

Water bars are used on roads, trails, and firelines where vehicular traffic is not anticipated. Specifications for construction and spacing are provided in the manual. Water bars should fully intercept ditch flow. Install an energy absorber at the water bar outlet to minimize erosion.

Inspect all structures frequently during ongoing operations and immediately following significant rain events to evaluate their effectiveness. Promptly correct conditions or situations that are ineffective.

9. Site Preparation and Reforestation

If preharvest planning does not address site preparation, then a Regeneration Plan should be prepared prior to commencing site preparation activities. Confine site preparation intensity to the minimum required to achieve planned results. Use chemicals, fire, or hand tools instead of heavy machinery on steep terrain or fragile soils. Do not allow debris to enter watercourses.

Firelines for prescribed burning should be constructed along the perimeter of the burn area and SMZs and should not be constructed in salt marshes, critical wetlands, or riparian areas. Firelines should be only as wide and deep as necessary to contain the burn and should be constructed following guidelines established for skid trails. On steep terrain, construct firelines by hand. If herbicides are aerially or broadcast applied on an SMZ, then prescribed burning in the SMZ is not advised because the chemical will intensify the burn. Prescribed burning should be conducted by trained and properly equipped personnel when soil moisture and atmospheric conditions are favorable.

Of various mechanical site preparation techniques, the use of shearing and drum chopping is preferable to disking, and a shear (KG) blade should be used instead of a straight blade. Do not operate bulldozers on slopes greater than 45 percent, in SMZs, or in ephemeral streams. Keep the dozer blade at least 3 inches above the ground surface, and do not expose more than 50 percent of the mineral soil. Windrows should be constructed along the contour, tightly packed, free of soil, and as narrow as possible. Recommended windrow spacing is provided, but spacing should be determined by slope, soil type and its erodibility, and the amount of vegetation to be sheared or pushed. Windrows should have openings at least 20 feet wide for each 600 feet

of length. When raking, use a toothed-type root rake rather than a blade, and do not penetrate the soil. Bedding should be performed along the contour and should not be connected to drainages. Furrrowing and scalping should follow the contour, should be less than 6 inches deep, and should not channel water into any drainage. Perform machine planting when site conditions are suitable and perform along the contour.

Pesticide use must follow manufacturer's label instructions, EPA guidelines, and the North Carolina Pesticide Board of Regulations and Laws. Carefully mix pesticides to avoid spills and to ensure that excessive amounts of chemicals are not being applied. Do not apply pesticides during unstable and unpredictable changing weather patterns, when surface wind speeds exceed 6 miles per hour, or when the temperature is 90°F or above. Use equipment and techniques that minimize drift; do not directly apply chemicals to surface water. Do not clean containers or application equipment in or near streams.

Apply fertilizer in accordance with manufacturer's label instruction and at rates reflecting tree species and soil needs. Do not broadcast apply fertilizers within 25 feet of open water and perennial streams.

10. Revegetating Disturbed Areas

Perform seedbed preparation only as needed. To ensure adequate establishment of grass and legumes, most disturbed sites will require application of lime and fertilizer. Apply lime and fertilizer evenly, and incorporate into the top 4 to 6 inches of soil. Apply seed uniformly using properly calibrated equipment. When hydroseeding, ensure that the ground surface is rough prior to application. Use certified seed for permanent seeding whenever possible, and mulch immediately after seed is applied. The choice of mulch should be based

on soil conditions, season, type of vegetation, and size of the area. Recommended mulching materials and rates are provided. Straw mulch must be anchored immediately after spreading. Seeding mixtures, applications rates, and application dates are provided on a regional basis. A guide on how to calculate seed and fertilizer needs for roads and disturbed areas is also included. Inspect seeded areas for failure, make necessary repairs, and reseed within the same season, if possible.

11. Wildfire Protection

Consider the following when fighting wildfires:

- bare no more ground than is necessary;
- avoid disturbing existing gullies; and
- when approaching or crossing streams, minimize damage to stream banks and stream channel areas.

After wildfire operations have ended, construct turnouts, waterbars, or other water control structures along firelines and provide ground cover on steep areas and within SMZs.

State Contact:

Whit Collier
Division of Forest Resources
(919) 733-2162

Other Available State Information

Manuals/ Books	<i>Pocket Guide to Forest Practice Guidelines</i> (1990)
Brochures	Forestry Leaflets: <i>Summary of Performance Standards</i> ; <i>Streamside Management Zones</i> ; <i>Suggested Provisions for Timber Sale Contracts</i> ; and <i>Becoming a Forest Steward in North Carolina</i>

OHIO

Reference: Ohio Department of Natural Resources, Division of Forestry. 1991. *BMP's for Erosion Control on Logging Jobs*.

BEST MANAGEMENT PRACTICES

1. Planning Logging Operations
2. Haul Roads
3. Skid Roads
4. Maintenance
5. Stream Crossings
6. Filter and Shade Strips
7. Landing
8. Sale Closing

1. Planning Logging Operations

Develop a preharvest plan including a map identifying property boundaries, streams and drainages, critical areas, road and trail locations, stream and drainage crossings, log landings and mill seats, buffer zones, and other environmental concerns. Also note road and trail specifications, harvesting equipment to be used, time of harvest, logging contract specifications, special planning for wet areas, and obstructions such as rock outcroppings. Cross streams at right angles. Construct small bridges or install culverts at live stream crossings and seeps. Roads leading down to a stream crossing should be drained. Logs should not be skidded through flowing streams.

2. Haul Roads

Locate roads on side slopes where side drainage is possible, and at grades between 2 and 10 percent. Steeper grades, 15 percent, can be used for distances up to 200 feet.

Avoid long, straight grades by following the contour. Use topographic maps to help locate roads. Avoid wet and critical areas.

Design the road to safely accommodate anticipated traffic volume and weight. Cut and fill slopes should not exceed a 2:1 ratio. Install side ditches where surface runoff endangers fill areas, and ensure good cross drainage through the use of turnouts, rolling dips, broad-based dips, pipe culverts, or open-top culverts. Specifications for construction of drainage structures are provided in the manual. When building in wet areas, use pervious fill material and surface the road with wooden mats or other appropriate material to prevent rutting. Gravel the haul road entrance when necessary to prevent mud from entering a highway.

Cross streams perpendicular to stream flow using bridges or culverts. If bridges or culverts are not feasible, ford streams where streambeds and banks are rock or stone and equipment can cross with a minimum of disturbance.

Maintain roads and drainage systems during construction and harvest. Do not operate during weather conditions that will generate excessive erosion and sedimentation. Control erosion during construction using temporary measures, such as hay or straw bales or silt fences across a slope or at the base of a slope.

3. Skid Roads

Locate landings first, and then plan major skid trails to minimize damage to the residual stand and reduce erosion potential. Locate skid trails along the contour at grades 20 percent or less, and avoid stream channels, rocky places, spring seeps, adverse grades, and wet areas. Do not locate skid trails in streamside filter or shade strips. Do not construct skid trails straight up the hill, but proceed slanting up the

slope. Avoid long, steep grades by following surface contours and occasionally changing direction. Cross streams perpendicular to stream flow, and construct temporary bridges, crossings, or culverts.

Upon completion of harvesting operations, remove stream-crossing structures as soon as possible. Stream crossings and channels should be clear of slash and restored to their natural shape and grade. Stabilize skid roads using water bars, logging debris, seed, and/or mulch.

4. Maintenance

During new road and landing construction, prevent entry of soil to waterways using temporary sediment barriers. Periodically inspect all drainage structures for obstructions. Recrown haul roads and skid roads, and watch for wet areas or seeps during rainy periods.

5. Stream Crossings

Construct small bridges or install culverts at live stream crossings and seeps perpendicular to stream flow. If bridges and culverts are not feasible, ford streams at right angles, where stream bottom is rock and banks are rock. Culverts placed in streams should be in line with the natural stream course, and the slope of the culvert should be slightly less than the slope of the streambed. Drain roads and skid trails away from the stream crossing, and apply gravel and rip-rap to skid road approaches. Logs should not be skidded through flowing streams.

6. Filter and Shade Strips

Filter strip widths are determined by the slope between the road and the stream. The minimum width is 25 feet, and increases by 20 feet for each additional 10 percent increase in slope. Filter strips should be wider in

municipal watersheds and critical areas. Shade strips are 25-foot areas on either side of stream banks that are not cut or are lightly cut to preserve adequate shading and maintain satisfactory stream temperature. Selectively harvest in filter strips. Minimize equipment operation in filter strips, and seed and mulch exposed soil. Do not skid in filter and shade strips, and limit skid and haul roads to stream crossings. Do not construct landings or yards in filter or shade strips. Install energy dissipators at culvert outlets where the culverts are not in the natural streambed at natural grade.

7. Landings

Landing locations should be planned before operations begin. Location should be determined by the size of the operation, the location and amount of timber to be harvested, ground conditions, drainage, skid road location, and safe access to the highway.

Locate landings outside filter and shade strips on dry sites with slight slopes. Provide adequate drainage on approach roads so that runoff does not enter the landing area. Upon completion of operations, remove all trash from the harvest site and revegetate landings and yards as soon as possible.

8. Sale Closing

Construct water bars on skid trails and haul roads that will not have vehicular traffic. Water bars should be installed at an angle 30 degrees to the road and an outslope of 2 to 3 degrees. Recommended water bar spacing and specifications are provided in the manual. Dissipate the discharge from water bar outlets onto the undisturbed forest floor. Pipe culverts, box culverts, or broad-based dips should be installed and maintained on roads that will continue to have traffic. Water bars and other erosion control devices should be

installed even on temporary or seasonal shut-downs. Reestablish vegetation on all areas that have exposed mineral soil as a result of logging operations, such as roads and decks. Within 1 year of sale closing, a 50 percent vegetative cover should be established. Apply lime, fertilizer, and mulch if necessary. Recommended seeding mixtures, seeding rates, fertilizer rates, and mulching guides are provided in the manual.

State Contact:

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Division of Forestry
(614) 265-6667

Other Available State Information

Brochures *Planting Filter Strips to
Improve Water Quality*

OKLAHOMA

Reference: Oklahoma Department of Agriculture, Forestry Division. 1985. *Forest Manager's Guide for Water Quality in Oklahoma*.

BEST MANAGEMENT PRACTICES

1. Streamside Management
2. Overall Management and Compartment Planning
3. Forest Roads
4. Harvesting
5. Site Preparation
6. Forest Chemicals
7. Firelines
8. Revegetation

1. Streamside Management

The objective of streamside management is to exercise caution when working near watercourses to prevent degradation of water quality. Protect streambeds and stream banks from damage by heavy equipment or logging operations. Removal of overstory vegetation is permissible, but the understory vegetation should be protected and quickly revitalized. Cable skidding should be used in streamside management zones. Do not use mechanical site preparation or prescribed burning in SMZs, and do not locate landings in SMZs.

2. Overall Management and Compartment Planning

When developing a management plan, determine the landowner's objectives and evaluate the proposed site. Use topographic maps, road maps, aerial photographs, soil surveys, and recent management plans for

adjacent sites, in addition to field reconnaissance, to evaluate the site's soil conditions, topography, drainage patterns, and timber cover. The Guide provides a Field Examination Summary that will aid the landowner and the forest manager in selecting management alternatives and recommending BMPs. These elements should be detailed in a written management plan. Sample management plans are also provided in the Guide.

Plan the layout of harvest areas and access roads considering erosional and water quality impacts. Where practical, place setting boundaries at perennial streams, roads, or changes in soil type, forest type, or topography. Design settings to optimize economic skidding distances, to minimize road densities and unnecessary road construction, and for efficient establishment and management of subsequent forest crops. Avoid leaving narrow, unmanageable strips of timber. Schedule operations to avoid wet weather and minimize adverse impacts on soils and water quality.

3. Forest Roads

Locate roads along the crests of ridges or along the contour and avoid locating in narrow canyons, marshes, wet meadows, natural drainage channels, and SMZs. Minimize the number of stream crossings, but when necessary cross perpendicular to streamflow. Use the minimum design standard necessary to accommodate the anticipated traffic load to minimize environmental impacts.

Limit right-of-way clearing and road construction to a width commensurate with the planned use of the road. Minimize the need for borrow pits by balancing excavation and embankments. Construct road cut slopes to minimize the potential for bank failures. Do not place fill material below the high water

mark of a stream, except when necessary at a stream crossing. Do not bury stumps or slash in the load-bearing portion of the road. Place logs or slash at the foot of slopes to trap sediment. Seed and mulch as needed. Do not continue construction during wet weather periods. Appendix B of the Guide provides technical guidelines for road construction activities, including installation of drainage structures.

Install ditches, culverts, cross drains, drainage dips, water bars, and diversion ditches concurrent with road construction. Install drainage structures at low points in the road gradient. Disperse road drainage onto undisturbed forest floor, and do not discharge drainage structures onto erodible soils or fill slopes unless outfall protection is provided. Properly size culverts to accommodate anticipated flow volumes.

When crossing watercourses, use bridges or culverts if fording would create rutting or siltation. Use low-water bridges and overflow culverts to minimize changes to the natural stream channel during periods of high water. Protect bridge approaches using rocky fill material, ground cover, riprap, concrete surfacing, or retaining walls and bulkheads. Bridges should not constrict clearly defined stream channels. Remove slash and debris generated from road construction activities from watercourses.

Periodically inspect roads to determine whether maintenance is required. Road surfaces should be crowned, out-sloped, or water barred to dissipate surface runoff and minimize erosion of the roadbed. Clear blockages from ditches and culverts. Revegetate or stabilize exposed soil areas.

4. Harvesting

Locate landings to minimize adverse impacts of skidding on the natural drainage pattern. Landings should be on firm ground outside SMZs of perennial streams and above the ordinary high water mark of intermittent streams. Landing size should be the smallest area required for safe logging. Provide adequate drainage for landings by out-sloping roads and skid trails above landing areas and by diverting drainage water and dispersing it onto the forest floor. Upon completion of operations, seed or install drainage structures to minimize erosion.

Harvest operations should match available equipment with the terrain, soils, and weather conditions to minimize soil compaction and disturbance. Locate skid trails to avoid steep gradients, streams crossings, SMZs, and disrupting natural drainage channels, and to take advantage of topography. Skidding should be upslope or on the contour to disperse runoff. Temporary stream crossings may be necessary to protect streambeds and stream banks and to minimize sedimentation. Occasionally break the grade on skid trails to facilitate diversion of water. Practice directional felling near streams, avoid felling trees in streams, and immediately remove any debris. Fell trees parallel to skid trails with butts toward the landing. Use cable skidding in SMZs. Upon completion of harvesting operations, skid trails should be water barred and temporary stream crossing should be removed. Revegetate erosion-prone areas.

Store fuel and lubricants away from watercourses where accidental spills would not result in contamination. Logging litter, such as oil cans, grease containers, crankcase oil, old tires, broken cable, paper, and other trash must be prevented from entering watercourses and should be disposed of properly.

5. Site Preparation

Prompt regeneration is essential to realize site productivity and to minimize soil erosion. Mechanical site preparation should be conducted in a manner that minimizes soil erosion and compaction and prevents the accumulation of debris in, or sedimentation of, water bodies. Limit the degree of site preparation to the amount necessary on a given soil type to achieve a well-stocked stand of the desired species. Do not conduct mechanical site preparation activities in SMZs.

Shearing and KG blading are best suited to rock-free areas with little slope and relatively large amounts of unmerchantable material to be removed. Where soils are highly erodible or low in nutrients, or on slopes greater than 10 percent, the adverse effects of the shearing-windrowing practice may outweigh any advantage. When shearing, minimize soil disturbance and displacement. Construct windrows along the contour and minimize the amount of soil incorporated.

Disk-harrowing with bedding and furrowing is often used on flat and gentle topography. Avoid disking on steep slopes with erodible soils. Disking of alternate strips on the contour may be an acceptable practice on certain side slopes. Provide water outlets on bedded or furrowed areas at locations that will minimize movement of sediment and discharge onto vegetated surfaces.

Do not rip along or across streams or natural drainage channels; rip along the contour. Provide for discharge of drainage water onto vegetated surfaces.

If drainage is necessary for the establishment and growth of commercial tree species, plan the drainage system to fit the topography and seasonal flow variations and to take advantage of natural drainage patterns. Design ditches

based on surface soil type, slope, depth to hard pan, and the volume of water to be controlled. Use cofferdams and other devices to gradually deliver initial discharges into natural waterways. Place ditch spoil material away from the edge of the ditch. Keep the drainage system clear of logging debris. Repair, revegetate, or stabilize ditch bank failure and erosion from side-cast material.

6. Forest Chemicals

Chemicals must be handled and applied in accordance with the manufacturer's label instructions and all applicable federal and state regulations. Do not permit chemicals to leak from equipment used for transportation, storage, mixing, or application. Do not mix chemicals near water bodies. Provide an air gap or reservoir between the water source and the mixing tank, and use uncontaminated pumps, hoses, and screens. Do not apply chemicals directly to surface waters. During aerial applications, use a spray device capable of immediate shutoff, and stop application during turns. Remove and dispose of chemical containers in a manner conforming to state regulations and label directions. Clean equipment away from water bodies, and dispose of residues in conformity with state requirements.

7. Firelines

Install practices to prevent channelized flow, improve drainage, and stabilize bare soil. Firelines constructed during prescribed burning activities or routine fire suppression should be water barred immediately. Firelines constructed during wildfire suppression should be water barred after the fire is extinguished. Bare areas on steep slopes should be revegetated.

8. Revegetation

Cultivate severely compacted areas. Scarify the surface when broadcast seed spraying. If site preparation is not completed within planting dates, stabilize the area with mulch and then plant during optimum planting dates. Planting should be performed as soon as possible after seedbed preparation is completed. The Guide provides optimum planting dates for various species. Mulch area with 1 pound per square yard of weed-free native hay to minimize erosion and retain moisture. Fence revegetated areas where necessary to protect from grazing or human activities. Fertilize as necessary to establish good cover.

State Contact:

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Forestry Division
(405) 521-3864

Other Available State Information

Videos *Logging BMPs and Water Quality*

OREGON

Reference: Oregon Department of Forestry, Forest Practices Section. 1991. *Forest Practice Rules, Eastern Oregon Region, Northwest Oregon Region, and Southwest Oregon Region.*

All timber operators and landowners in the state of Oregon must comply with the Rules. The *Oregon Forest Practice Rules* are currently being revised and are projected to be complete in 1993.

BEST MANAGEMENT PRACTICES

1. Notification and Written Plans
2. Leakage or Accidental Spill of Petroleum Products
3. Riparian Management Areas
4. Application of Chemicals
5. Disposal of Slash
6. Reforestation
7. Road Construction and Maintenance
8. Harvesting

1. Notification and Written Plans

The operator, landowner, or timber owner shall notify the State Forester at least 15 days prior to the commencement of the following operations:

- Harvesting of forest tree species;
- Construction, reconstruction, and improvement of roads;
- Application of pesticides and fertilizers;
- Site preparation for reforestation involving clearing or use of heavy machinery;

- Clearing forest land for conversion to any nonforest use;
- Disposal or treatment of slash;
- Precommercial thinning;
- Cutting of firewood, when the firewood will be sold or used for barter.

Approval of a written plan must be obtained before conducting operations within 100 feet of a stream classified as a Class I water (having important fish or domestic use); within 300 feet of a specific site involving threatened or endangered wildlife species or sensitive bird nesting; within 300 feet of any nesting or roosting site of threatened or endangered species listed by the U.S. Fish and Wildlife Service or the Oregon Fish and Wildlife Service; or within 300 feet of a significant wetland. The written plan must contain specific information applicable to the operation including, but not limited to, the following: location of roads and landings, road and landing design, construction techniques, drainage systems, disposal of waste materials, felling and bucking, buffer strips, yarding systems and layout, riparian management area protection measures, resource site protection measures, and postoperation stabilization measures.

2. Leakage or Accidental Spill of Petroleum Products

Adequate precautions are to be taken to prevent leakage or accidental spillage of any petroleum products so that the products will not enter waters of the state.

3. Riparian Management Areas

The riparian management area is along each side of a Class I water, and special management practices are required to protect

water quality, aquatic habitat, and wildlife habitat. The boundaries of the riparian management area need not be formed by straight lines. The width of the area may vary depending on topography, vegetative cover, the needs of the harvesting design, and the needs for aquatic and wildlife habitat. Requirements are set for the average width of the riparian area for streams, estuaries, lakes and wetlands.

4. Application of Chemicals

Equipment used for transportation, storage, or application of chemicals must be leakproof. When water is taken from any stream or water impoundment for use in mixing chemicals, an air gap or reservoir must be provided between the water source and the mixing tank, or a portable pump should be used. When spraying chemicals by aircraft, leave an unsprayed strip of at least 60 feet on each side of every Class I water or area of open water, and areas adjacent to inhabited dwellings. When applying chemical spray from the ground, leave an unsprayed strip of at least 10 feet on each side of every waterway or area of open water. Application of chemical spray in or adjacent to the riparian area of influence must be made parallel to waterways and prior to application to the remainder of the area to be treated. Mix chemicals and clean tanks or equipment only where the chemicals will not contaminate waters of the state. Locate mixing areas and aircraft landing areas where spillage of chemicals will not contaminate waters of the state. Immediately contain and neutralize any chemical spills. Rinse chemical containers with the carrier used in mixing at least three times.

A daily record must be maintained for each application of a pesticide and should include:

- name of monitor or name of applicator;

- location of project;
- hourly temperature, wind velocity, and wind direction;
- contractor's name (and pilot's name when applied aerially);
- pesticide name, mixture, application rate, and carrier used; and
- disposal method and location of containers.

5. Disposal of Slash

Reduce the volume of debris as much as possible. Dispose of or disperse unstable slash accumulations around landings to prevent their entry into streams. When treating competing vegetation, plan harvesting practices to break up or destroy such vegetation; follow up with chemical application and/or burning if necessary. Burning is not allowed in riparian areas along a Class I water. When burning in riparian areas of influence, protect aquatic and wildlife habitat such as downed logs and snags.

6. Reforestation

Whenever stocking is reduced below either 25 percent of estimated crown closure, or 80 square feet of basal area per acre of trees 11 inches DBH or larger, 150 well-distributed seedlings or saplings per acre must be established. (These stocking provisions are currently under review to increase stocking of free-to-grow seedlings).

7. Road Construction and Maintenance

Locate roads to minimize risks of material entering waters of the state by fitting the road to the topography and avoiding steep, narrow canyons, slide-prone areas, steep headwalls, slumps, marshes, meadows, riparian

management areas, or existing drainage channels. The rules require minimizing road density in high-risk areas. Design roads to minimum use standards adapted to the terrain and soil, and to drain naturally by out-sloping and through grade changes. Provide dips, water bars, and cross drainage, and divert water from natural drainage ways. Design cut-and-fill slopes to minimize the risk of mass soil movement. Deposit end-haul and other excess material in stable locations above the high water level and clear drainage ways of woody debris. Stabilize exposed soil that is potentially unstable or erodible by using seeding, compacting, rip-rapping, benching, leaving light slashing, or similar means.

Minimize stream crossings, and cross streams at right angles to the main channel. Design water crossing structures to provide for adequate fish passage, minimize impacts on water quality, and have the capacity to accommodate the 25-year storm. Design culvert installations to prevent erosion of the fill. Minimize machine activity in streambeds, and install drainage structures on live streams as soon as feasible. Changes are not to be made in natural fish-bearing stream courses by filling, by removal, or by relocation of the channel, except by written approval from the State Forester.

Maintain and repair active and inactive roads as needed to minimize damage to waters of the state. Restore road surface crown or out-slope all roads prior to the rainy season. Clean culvert inlets and outlets, drainage structures, and ditches before and during the rainy season. Prevent entry of road oil or other surface-stabilizing material into waters of the state.

8. Harvesting

Select for each harvesting operation the logging method, size of equipment, and type of equipment best adapted to the given slope,

landscape, and soil materials to minimize soil deterioration. Minimize machine and yarding activity, fell timber directionally away from waters, remove all slash from waters, and retain or reestablish undergrowth vegetation. Avoid tractor or wheel skidding on unstable, wet, or easily compacted soils and on slopes that exceed 35 percent, and locate skid trails where sidecasting is kept to a minimum. Locate skid and fire trails so they are not in the riparian management area, except when using temporary crossings. Avoid tractor skidding in or through any stream. When crossing streams, provide temporary structures adequate to carry stream flow, which are to be removed immediately after use. Install water diversion structures or water bars on all tractor or skidder trails before the rainy season.

Uphill cable yarding is recommended. Use a yarding system that will minimize soil disturbance when downhill yarding or when yarding across high-risk sites. Avoid cable yarding through Class I streams. If it is necessary to yard across streams, swing the yarded material free of the ground in the aquatic and riparian areas. Minimize disturbance to the channel and stream bank vegetation when cable yarding in Class II waters, and leave 75 percent of the original shade along Class IIS waters.

Minimize landing size and locate landings on stable areas. Do not locate landings in riparian management areas. Provide and maintain cross drains, dips, water bars, and other water diversion structures. Upon completion of operations, stabilize potentially unstable or erodible soils by seeding or placing slash, and reestablish drainage on landings after use. Prevent entry of debris, overburden, and other waste material associated with harvesting from entering waters of the state. Remove waste from logging operations and dispose of waste properly.

A riparian management area must be maintained along each side of Class I waters. In riparian management areas adjacent to Class I waters, an average of 75 percent of the pre-operation shade must be maintained over the aquatic area; at least 50 percent of the pre-operation tree canopy must be maintained; and conifers must be retained in the half of the riparian management area closest to the water (or within an average 25 feet of the water, whichever is greater).

State Contact:

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Other Available State Information

Brochures *Waterbars; Road Maintenance;
Ditch Relief Culverts; Riparian
Protection*

PENNSYLVANIA

Reference: Pennsylvania Department of Environmental Resources, Bureau of Soil and Water Conservation. *Controlling Erosion and Sedimentation From Timber Harvesting Operations.*

This manual is currently being revised.

Three State laws pertain to forest harvesting operations and water quality: the Clean Streams Law, the Fish and Boat Code—Act 175, and the Dam Safety and Encroachment Act. The administrative code (Title 25, Chapter 102) is designed to implement the Clean Streams Law. Chapter 102 requires that a permit be obtained prior to the commencement of any earthmoving activity in excess of 25 acres.

The Clean Streams Law mandates that persons conducting earth-disturbing activities must develop a plan designed to implement and maintain erosion and sedimentation prevention measures. The soil erosion and sedimentation control plan should address the following areas: (1) design of the road system; (2) water control structures; (3) stream crossings; (4) log landings; (5) haul roads, skid roads, and skid trails; (6) maintenance; (7) road use; and (8) road and log landing retirement.

The Fish and Boat Code stipulates that no person may alter or disturb any stream, stream bed, fish habitat, water or watershed in any manner that might cause damage to or loss of such without necessary permits.

The Dam Safety and Waterway Management Rules and Regulations require a permit to construct, operate, maintain, modify, enlarge, or abandon any dam, water obstruction, or encroachment.

BEST MANAGEMENT PRACTICES

1. Road Systems
2. Water Control Structures
3. Stream Crossings
4. Log Landings
5. Haul Roads, Skid Roads, and Skid Trails
6. Road and Log Landing Retirement

1. Road Systems

The siting and construction of roads should be conducted using aerial photographs, topographic maps, and soil surveys to aid in the planning. Topographic maps should be used to plan the road system around very steep lands, spring seeps, boulders, rock outcrops, and other obstructions. Soil surveys can be used to avoid sites with soils unsuitable for road construction. When possible, construct roads on side hills for good cross-drainage.

A road grade of 2 to 8 percent is desirable; grades of up to 20 percent may be used for short distances. When steep grades are necessary, provide 300 feet of road above and below where slopes are less than 10 percent. Where stream crossings are necessary, cross at a right angle to the stream and approach from a gentle slope. Where roads will be constructed near perennial streams, provide adequate filter strips. The width of the filter strip will depend on the slope of land between the road and the stream. Table 28 presents the recommended filter strip widths. Minimize soil disturbance within filter strips, and apply stabilization measures when soil is exposed and likely to cause sedimentation.

To prevent excessive water runoff from road surfaces, roads should be out-sloped or in-sloped. In-sloped roads should have a slope

Table 28. Filter Strip Widths

Slope (percent)	Filter Strip Width ^a (feet)
0	25
10	45
20	65
30	85
40	105
50	125
60	145
70	165

^a Widths should be doubled when harvesting is adjacent to municipal water supplies.

rate of 0.25 to 0.375 inch per foot of road width. In-sloping roads is preferred to out-sloping.

2. Water Control Structures

The spacing for all water control structures should protect against erosion and sedimentation under severe conditions. Figures and tables are provided in the manual with suggested spacing and construction specifications for culverts. The minimum recommended size for a culvert is 12 inches. The culverts should be installed with a slope of 2 to 4 percent and should be long enough to extend at least 1 foot beyond the fill material. Riprap or some other type of energy dissipator should be placed at the culvert outlets.

Broad-based dips may be used instead of culverts where no intermittent or perennial streams are present. They may be used where road grades do not exceed 10 percent. A figure and table are provided in the manual to aid in construction and spacing of broad-based dips. The dip should divert water into undisturbed areas or into energy dissipators such as 3-inch-diameter crushed stone.

Water bars are advantageous for water control on retired roads and when the expected volume of runoff will be marginal. A table and figure are provided with recommended water bar spacing and construction specifications.

3. Stream Crossings

Preplan road sites to limit the number of stream crossings. When stream crossings are unavoidable, cross perpendicular to the stream flow. Culverts are the most common method of stream crossing. Culverts should be placed in the natural stream drainage channel and should be graded the same as the stream. Avoid placing fill below the culvert to obtain the grade. The culvert should be large enough to carry potential storm flows. A table is provided to aid in selection of an appropriately sized culvert. Fords may be used for crossing streams with haul roads but not for skid roads or skid trails. When skid trails or skid roads must cross a streams, culverts or temporary moveable bridges should be used. Only streams with low banks and solid streambeds are suitable for ford crossings.

4. Log Landings

Retain adequate filter strips between log landing locations and streams. Recommended filter strip widths are provided in Table 28. Diversion ditches should be constructed above landings to prevent surface runoff from flowing onto the landing. Disturb only the area needed for the actual operations. Provisions should be made to prevent water from skid trails or skid roads from flowing onto the log landing. Several types of diversions are illustrated in the document.

5. Haul Roads, Skid Roads, and Skid Trails

The slope, soil type and condition, and surface drainage should be considered prior to

constructing haul roads and skid roads. Skid roads should be designed to avoid problem areas such as spring seeps, streams, rocky places, and long lengths of constant slope. Keep the grades of skid trails and roads as shallow as the topography will permit; do not go straight up the slope. If skid trails must be placed straight up the slope, the construction of water bars should be considered. Never skid through or across stream channels or spring seeps. Bridges or culverts should be installed to cross streams.

Prevent the accumulation of surface water on road surfaces by using dips, water bars, culverts, in-sloping, and/or out-sloping to divert water from the road surface. Maintain road surfaces in a manner that prevents ruts, curbs, or logging debris from restricting drainage. Overhanging trees should be removed to facilitate road surface drying. Road surfaces should be graded occasionally and dips, water bars, and other diversion structures should be reshaped. Reduce or eliminate traffic during unfavorable weather.

6. Road and Log Landing Retirement

The erosion and sedimentation plan developed should have provisions for the retirement of haul roads and landings. The roads should have their surfaces smoothed and reshaped. Culverts should be replaced with water bars, broad-based dips, or ditches. If culverts are covered by more than 2 feet of fill, consider leaving them in place, but include provisions for their maintenance. Remove all temporary stream crossings. Seed, mulch, lime, and fertilize critical areas near streams or where erodible or otherwise unstable soils exist. A table is provided with seeding mixtures and rates.

RHODE ISLAND

Reference: Cassidy G.J., and J.B. Aron.
Best Management Practices: DRAFT. Rhode Island Department of Environmental Management, Division of Forest Resources.

BEST MANAGEMENT PRACTICES

1. Logging Roads and Skid Trails
 - a. Planning and Construction
 - b. Maintenance
2. Landings
3. Wetlands
4. Forest Protection
 - a. Insects and Disease
 - b. Fire

1.a. Logging Roads and Skid Trails: Planning and Construction

Preplan the location of access system components using topographic, soils, wetland, and vegetation maps in addition to field reconnaissance. Maintenance of existing drainage patterns is desirable. Determine landing sites before locating roads and trails. Locate roads on side slopes away from wet areas, streams, ledges, steep slopes, and rock outcrops. The grades of logging roads and skid trails should be less than 10 percent, with 3 to 5 percent being the most desirable. Avoid long, straight grades and occasionally break the grade to provide surface drainage. Construct skid trails and roads from the highest elevation down.

Streambeds should never be used for roads. Retain a filter strip between watercourses and logging roads. A table is provided that recommends widths for filter strips based on slope. However, width should be determined

by site conditions and should be greater when the watercourse is in a municipal watershed, contains important fisheries or wildlife, or has steep banks. Minimize the number of stream crossings, and cross streams perpendicular to stream flow. Stream crossings should be located where the bank and streambeds are stable and where the approaches will be fairly level. If possible, use existing bridges or culverts.

Install water diversion structures where needed to facilitate drainage of water from the road surface, and discharge runoff away from streams. Suggested distances between culverts and broad-based dips are provided.

1.b. Logging Roads and Skid Trails: Maintenance

When roads and skid trails are properly located and constructed, maintenance problems are minor. To maintain roads in good condition and to reduce erosion, avoid use during poor weather and install temporary drainage structures when operations will be delayed. Periodic grading may be necessary to maintain the road surface at its original gradient.

Upon completion of harvesting operations, eliminate ditches and remove ruts, berms, damaged trees, and other hazardous obstacles. Restore stream crossings to their original condition. Temporary drainage structures should be replaced with permanent measures. Disturbed areas should be revegetated to stabilize the soil. Access to the areas should be restricted.

2. Landings

Landings should be located on slight slopes outside wetland areas and should be well-drained. Use hay bales or other erosion control devices to reduce erosion and

sedimentation. Gravel the entrance to prevent mud and other debris from being transported onto paved roads. Upon completion of the harvesting operation, regrade and seed landing areas.

3. Wetlands

Roads in wetland areas should be constructed and maintained in accordance with the best management practices previously outlined, and every attempt should be made to retain the site's natural hydrologic flow and characteristics. Use existing bridges or culverts when crossing streams. Temporary crossings are permissible, but disturbed areas should be restored to their original condition.

Forested wetlands may be harvested, but post-harvest stocking must be at least 50 percent on the appropriate stocking guide. Harvesting should not occur more frequently than every 3 years. During periodic harvests, care should be taken to avoid soil puddling and compaction, and to prevent damage to the residual stand. Harvest should be conducted at the driest time of the year or when the ground is frozen.

A buffer zone where forestry activities are limited should be established to protect the watercourse from degradation. The optimal size of the zone is related to the slope, depth to water table, soil type, the type of vegetation, and intensity of management, but the zone must be at least 25 feet wide.

Do not disturb vernal pools when logging. Locate landings and skid trails away from these areas. Avoid compacting or disturbing the soil in or near the pools and avoid creating ruts greater than 6 inches deep within 200 feet of the pools. Retain an uncut buffer strip adjacent to vernal pools that is at least 25 feet wide.

4.a. Forest Protection: Insects and Disease

Periodically inspect forest stands for signs of forest pests. Cultural treatments are recommended to control insects and disease. These include silvicultural treatments that alter forest stands to reduce the likelihood of attack and/or to prevent losses. An area will be less susceptible to a large outbreak if diversity is encouraged. Perform sanitation treatments to remove the source of the infestation. Change stand composition to less susceptible species by favoring non-host species when thinning or planting. Thinning treatments can also be performed to promote the growth and vigor of desirable trees. Overmature stands can be regenerated to produce new crops of vigorous young trees.

4.b. Forest Protection: Fire

To protect forest stands from fire, use spark arresters on equipment, reduce fuels, and prohibit smoking on high and extreme fire days. Provide and maintain access roads to all parts of forest stands to aid in wildfire fighting. Do not use fire to reduce slash without the proper permits from the appropriate authorities.

State Contact:

Tom Bourn
Director of Forestry
(401) 647-3367

SOUTH CAROLINA

References: South Carolina Forestry Association. 1988. *Voluntary Forest Practice Guidelines for South Carolina*; and South Carolina Forestry Commission. 1989. *Best Management Practices for South Carolina's Forested Wetlands*.

A revised manual that will include wetlands and more recommendations related to nonpoint source pollution is being prepared. South Carolina has an ongoing biannual monitoring program to check for BMP implementation compliance as well as effectiveness. The effectiveness monitoring uses the benthic macroinvertebrate method.

BEST MANAGEMENT PRACTICES

1. Access Roads
2. Wetlands
3. Prescribed Burning
4. Fertilization
5. Harvesting
6. Site Preparation
7. Use of Herbicides

1. Access Roads

Plan access roads using topographic maps, soil surveys, and aerial photographs where available. Fit the roads to the topography, using ridge tops and developing the road along the contour. Avoid steep, narrow ridges, slide areas, gullies, marshes, stream channels, and ponds. Plan roads to avoid stream crossings whenever possible. When stream crossings are necessary, construct structures perpendicular to the stream channel.

During road construction balance cuts and fills to minimize borrow pit areas and the amount of soil that must be moved. Where construction of bridges is necessary, they should have sufficient capacity to accommodate increases in stream flow. Culverts should also be sized to accommodate increases in stream flow. Avoid building bridges during wet weather when the threat of erosion is increased. Clear stream channels of all debris produced during the road construction. Seed, fertilize, and mulch to insure a good vegetative cover on disturbed soils. Provide adequate cross drainage on road surfaces, and divert water into areas with good ground cover.

Maintain road surfaces by grading and out-sloping when necessary. Inspect and clean all drainage structures at regular intervals. Where natural cover will not be established quickly, seed abandoned roads with grass to prevent excess water runoff and erosion.

2. Wetlands

Road construction within forested wetlands should be kept to a minimum and should parallel the flow of water when possible. Specifications for road construction are provided in the manual. Natural generation should be encouraged as much as possible. Harvest activities should be conducted during dry periods to minimize water quality impacts and soil compaction. Avoid felling trees into active or well-defined intermittent streams; trees felled into streams should be removed as soon as practical. Locate log decks away from streams on the highest ground possible. Wheeled or tracked vehicles should not be used within 40 feet of a navigable stream if slopes are less than 20 percent, and 80 feet if slopes are greater than 20 percent.

3. Prescribed Burning

Before prescribed burning may be conducted, the landowner must authorize the use of prescribed burning on his/her land (Section 16-11-150 of the Code of Laws of South Carolina 1976). Weather forecasts must be monitored to provide information on sudden wind shifts. Avoid burning in areas subject to severe erosion.

4. Fertilization

Fertilizer applications should be conducted according to label requirements. Soil samples should be analyzed to assure proper fertilizer selection, application method, and application rate.

5. Harvesting

Landings and skid trails should be limited in number and size to prevent excess soil movement into streams. Keep stream crossings to a minimum; where crossings are necessary, provide protection to the stream bank and cross at right angles to the stream channel. Skid trail grades should be kept to a minimum. Exercise caution when conducting harvest operations with buffer strips along streams. Fell and skid trees away from streams to minimize damage to the stream bank. Retain a streamside management zone to minimize soil disturbance adjacent to stream banks. The width of the SMZ will depend on the size and flow of the stream, adjacent topography and soil, and shade requirements to protect stream water temperature. Service all harvesting equipment away from streams and other water bodies. Encourage the proper disposal of general refuse, litter, and waste oil and lubricants associated with timber harvesting operations.

6. Site Preparation

Mechanically prepare the site along the contour of the land. Of the mechanical site preparation techniques, chopping has the least impact on the site. On extremely steep slopes, use an approved herbicide rather than mechanical site preparation. Windrow debris along the contour or in gullies or skid roads to stabilize them. If drainage ditches are to be needed, they should be constructed prior to any reforestation effort.

7. Use of Herbicides

The application of herbicides should be conducted with the assistance of professional foresters. Aerial application of pesticides is not permitted within 80 feet of each side of a navigable stream.

State Contact:

Tim Adams
South Carolina Forestry Commission
(803) 737-8800

Other Available State Information

Manuals/ Books	<i>Best Management Practices's for South Carolina's Forested Wetlands; A Survey of Voluntary Compliance of Forestry Best Management Practices</i>
Brochures	<i>Let's Lead the Way with Best Management Practices; Forestry BMPs ... A Woodland Owner's Guide to Good Stewardship</i>
Videos	<i>Let's Clean Up Our Act; Let's Lead the Way</i>

TENNESSEE

Reference: Tennessee Department of Conservation, Division of Forestry. 1989. *Best Management Practices for Silvicultural and Other Forest Activities in Tennessee.*

BEST MANAGEMENT PRACTICES

1. Access Roads
2. Harvesting
3. Mechanical Site Preparation
4. Machine Planting of Tree Seedlings
5. Prescribed Fire
6. Pesticide Use
7. Livestock Exclusion
8. Streamside Management Zones
9. Revegetation of Disturbed Areas

1. Access Roads

Carefully plan road locations prior to construction activities. Locate roads near crests of ridges on side slopes and away from streams. Avoid swamps, seeps, fragile soils, steep slopes, and other obstacles. Establish streamside management zones between watercourses and roads. The widths of the SMZs will vary depending on the steepness of the slope. Minimize the number of stream crossings, and when necessary, cross perpendicular to stream flow.

Construct roads several weeks prior to commencing harvesting activities to allow the roads to settle. Avoid construction during wet periods. When clearing the right-of-way, push logging debris to the downhill side and evenly spread it to serve as a filter. Road grades should range from 3 to 10 percent. Grades up to 20 percent are acceptable provided road drainage structures are installed. Balance cuts

and fills. Stumps, logs, and other logging debris should not be incorporated into fill material.

The type and number of road drainage structures will depend on the slope, soil type, and equipment used. Diversion of water from the road surface may be accomplished through out-sloping, in-sloping, crowning, dips, and culverts. For roads constructed on gentle and moderate slopes, out-slope the road toward the fill bank at the rate of ¼-inch per foot. Roads with steep sharp turns or slippery soils should be in-sloped and have cross drainage installed. Crown roads on flat or gentle slopes. Dips may be used to divert water from road surfaces with slopes less than 10 percent. Culverts should be at least 15 inches in diameter and should be installed so that at least 2 feet of pipe extends beyond the fill material on both ends. Dips and turnouts should be constructed on roads to divert runoff water before it enters streams. Protect discharge area with heavy litter, grass sod, rock, or other material that will dissipate the runoff. Specifications for drainage structure installation and spacing are provided in the manual.

Stream crossings should be avoided when possible. When necessary, fords, culverts, and bridges should be constructed at right angles to the stream, but should not interfere with stream flow. Fords are acceptable only when stream bottoms are solid and streams are too wide for culverts or bridges. Culverts are recommended for crossing relatively small streams; specifications for culvert installation are provided in the manual.

Inspect roads after periods of rain, and remove all sediment and debris from drainage structures. Upon completion of operations, roads should be graded and smoothed. Water diversion structures should be installed to divert surface water into vegetated areas.

Roads constructed on steeper slopes should be seeded to revegetate as quickly as possible.

2. Harvesting

Log landing locations should be planned in advance of harvest operations; haul roads and skid trails should be located to reach the landings. Landings should be located away from streams to maintain appropriate SMZs. Log landings should be constructed to allow for natural drainage from the deck, but the slope should not exceed 5 percent. Landings should not be larger than necessary for the logging operation. Water turnouts should be installed above the landings to divert surface water around the landing. Landings should be revegetated following logging activities.

Skid trails should be planned in advance to reduce their number and impact. They should be located on grades less than 10 percent, although grades up to 30 percent are acceptable for short distances. Skid trails should not cross swampy areas, seeps, springs, or rocky or steep slopes. Skid trails should be constructed along the contour when possible, with grade breaks as often as possible. Logs should be skidded uphill following a zig-zag pattern. SMZs should be established adjacent to streams. Avoid skidding within SMZs and streams; cross at right angles to the stream when necessary. Water diversion structures should be installed on skid trails, especially above steep pitches and below seeps and springs. Retired skid trails should have water bars installed or repaired and should be shaped, smoothed, and revegetated.

Logging debris should be kept out of drains, streams, and other bodies of water. When necessary, remove logging debris from the stream and place it above the high water mark. Portable sawmills and chip harvesters should be located as far from streams as possible. Service and maintain vehicles and equipment

in areas where spills, oil, grease, or other toxic substances cannot enter streams. Provisions should be made to dispose of hazardous materials, human wastes, and garbage.

3. Mechanical Site Preparation

Site preparation methods should be chosen based on the amount, size and type of vegetation present; slope; and soil erodibility. Choose a method that disturbs as little soil as possible. Chemical treatments should be favored on steep slopes and highly erodible soils. Mechanical methods should be confined to slopes less than 30 percent. SMZs should be established between site preparation areas and streams. Mechanical site preparation should be conducted along the contour. Avoid operating heavy equipment during wet weather. Locate windrows away from drains to prevent debris from washing into streams. Windrows should be spaced between 100 and 300 feet, with occasional breaks to prevent damming.

4. Machine Planting of Tree Seedlings

Operate tree planting machines along the contour of the land when possible. Do not operate on slopes exceeding 20 percent.

5. Prescribed Fire

Prescribed burning must be conducted under strict wind, temperature, and humidity conditions. Avoid hot burns on sloping lands because the destruction of litter increases the chance of raindrop erosion. Avoid burning on excessively steep slopes or on highly erodible lands. Firelines should be constructed in straight lines, avoiding abrupt changes in direction. When possible, firelines should not be constructed on slopes exceeding 10 percent although slopes of up to 30 percent for short distances are acceptable. Construct water bars

and wing ditches along the firelines at recommended intervals. SMZs should be maintained between the prescribed burn area and streams. Firelines on steep slopes should be revegetated as needed.

6. Pesticide Use

Pesticides should be stored where there is no danger of release into the environment. Mixing activities should be conducted as far from water bodies as possible. Weather conditions such as rain, wind speed, temperature, and humidity should be monitored during pesticide applications to prevent drift and volatilization. Pesticides should never be applied directly to the water unless the pesticide is approved for application to water. Buffer strips of 100 feet for aerial, 50 feet for ground vehicle, 25 feet for hand spray, and 15 feet for hand dispersion applications should be maintained. Spray equipment and containers should be cleaned away from bodies of water. Excess chemical should be disposed of within the treated area. Dispose of containers in legal disposal areas or in accordance with label instructions.

7. Livestock Exclusion

Woodland grazing causes more loss of soil from Tennessee forestland than any other activity. Livestock should be excluded from woodlands when slopes exceed 10 percent. Plant shade trees on gentle slopes for livestock use.

8. Streamside Management Zones

The width of streamside management zones is dependent on the slope of the land between disturbed areas and streams. Table 29 presents the recommended SMZ widths.

Commercial harvest within the SMZ is permitted, but the logs should be removed by

Table 29. Recommended SMZ Widths

Slope (percent)	SMZ width (feet)
0	25
10	45
20	65
30	85
40	105
50	125
60	145

winching or animal skidding when possible. Avoid equipment operation within the SMZ. Trees should be felled away from streams. When trees are felled into the water, however, they should be removed by winching. Harvest debris should be removed from the stream and placed above the high water mark of the stream. Pesticide use is permitted within the SMZ. At least 50 percent of the trees adjacent to stream must be left to provide shade to the stream. Mechanical site preparation is prohibited within the SMZ.

9. Revegetation of Disturbed Areas

Road surfaces, cuts, fills, and ditches should be immediately revegetated after road construction. Skid trails, log landings, and other areas disturbed by harvesting activities should be revegetated as soon as possible after logging operations cease. Road surfaces should be shaped and smoothed prior to seeding. Heavily compacted areas may need scarification or disking to promote water infiltration. Seeded areas should be mulched to hold the seed, lime, and fertilizer in place. Seeding, fertilizer, and lime application rates are provided.

State Contact:

Robin Bible
Forest Hydrologist
Water Quality Management Program
(615) 360-0737

Other Available State Information

Manuals/ Books	<i>Best Management Practices for Protection of the Forested Wetlands of Tennessee (1990); Logger's Guide to Forestry BMPs; A Nonpoint Source Management Plan for Forestry Activities in Tennessee; BMPs and Timber Harvesting</i>
Brochures	<i>Clean Water from Tennessee's Forests; Forestry BMPs Work; Pickett State Forest; BMP Effectiveness Study</i>

TEXAS

Reference: Texas Forestry Association. 1989. *Texas Best Management Practices for Silviculture*.

This manual is in the final stages of revision and is being reviewed by the Soil and Water Conservation Board's various committees and affected soil and water conservation districts. Some significant changes will be made to the previous BMPs. Most notably, SMZs will be required on intermittent streams as well as perennial streams.

BEST MANAGEMENT PRACTICES

1. Planning
2. Road Construction and Maintenance
3. Harvesting
4. Mechanical Site Preparation/Planting
5. Fire
6. Silvicultural Chemicals
7. Streamside Management Zones

1. Planning

Use topographic maps, aerial photographs, and soil surveys in combination with field reconnaissance to determine site conditions and plan operations. Use natural drainage channels as harvest setting boundaries and plan skidding away from these channels. Setting boundaries should use topographic terrain, roads, and forest area size consistent with available logging equipment, planting schedules, and other silvicultural management objectives.

Setting design should be planned to balance skidding distances against road densities, and to avoid leaving narrow, unmanageable strips of timber susceptible to windthrow. On wet

soils with seasonal water problems, schedule operations to minimize adverse impacts on soils and water quality.

2. Road Construction and Maintenance

Locate roads along the contour and avoid confined terrain or natural drainage channels, marshes, wet meadows, and streamside management zones. Road grades should range from 2 to 10 percent. Steeper gradients, not exceeding 15 percent, are permissible for distances not exceeding 200 feet. Minimize the number of stream crossings and cross perpendicular to stream flow. Use the minimum design standard and width necessary to accommodate the anticipated traffic load.

Remove or deck right-of-way timber outside borrow ditches. Balance cuts and fills so that excavated material will be deposited in roadway fill sections, and construct cut-and-fill slopes at the normal angle of repose or less. Do not place sidecast or fill material below the ordinary high water mark of any stream except where needed to stabilize stream crossings. Gravel the road surface if necessary to maintain stability. Seed and mulch areas with high erosion potential.

Design roads to drain naturally using crowning, ditches, culverts, dips, and/or out-sloping. Provide cross drainage where needed. Install ditches, culverts, cross drains, and wing ditches at low points in the road gradient. Cross drains, relief culverts, and wing ditches should not discharge onto erodible soils or over erodible fill, but should discharge onto undisturbed forest floor or energy-absorbing materials. Size culverts to accommodate anticipated water flow. Specifications for the construction and spacing of drainage and erosion control structures are provided in the guide.

Construct stream crossings to minimize disturbance to banks and existing channels. Do not construct stream crossings during periods of high water flow. Crossing structures should not impede stream flow or fish passage. Culverts should have a minimum diameter of 15 inches. A chart for determining culvert size is provided in the guide and is based upon soil type and watershed drainage area. Use fords only when rutting or siltation would be minimal, and minimize machine activity in the streambed. Remove excess material and woody debris generated during construction from streams and drainageways, and deposit above the ordinary high water mark. Remove temporary crossings immediately after use.

Restrict traffic on roads during unfavorable weather conditions to minimize erosion and maintenance needs. The road surface should be crowned or out-sloped to dissipate surface runoff and minimize erosion of the roadbed. Remove obstructions and debris from ditches and culverts. Revegetate or otherwise stabilize exposed soil areas. Periodically inspect closed roads, and reestablish vegetation between roads and streams, if necessary.

3. Harvesting

Locate landings and portable sawmill sites prior to road construction. Landing locations should minimize the adverse impact of skidding on the natural water drainage pattern and should be on firm, well-drained ground at least 50 feet from SMZs. Landings should have a slight slope to provide for drainage. Disperse runoff water from landings and roads. Provide the shading, soil stabilization, and water filtering effects of vegetation along streams.

Do not use stream channels as skid trails. Locate skid and fire trails so that they do not run parallel to any stream when they are

within the average high water level of the stream. When stream crossing is necessary, use the most direct route, taking advantage of natural fords with firm bottoms, stable banks, and gentle slopes along approaches. Skid trails on slopes should have occasional breaks in grade and should be water barred and seeded when necessary.

Fell trees directionally away from streams, parallel to the skidding direction and with butts toward the landing. Do not harvest trees on the banks of streams within the SMZ. When cable yarding across streams cannot be avoided, streamside vegetation should be left undisturbed to the maximum extent possible. Remove any logging debris that accidentally enters watercourses.

Service equipment away from streams and in areas where accidental spillage would not result in stream contamination. Debris on landings should not be deposited into drainages or streams. Mulch or seed erosion-prone areas. Remove litter associated with the logging operations from the area and dispose of it in designated landfills.

4. Mechanical Site Preparation/Planting

Plan equipment use to minimize site disturbance as much as possible, especially in the SMZs. Avoid heavy mechanical site preparation on slopes greater than 30 percent or on highly erosive soils. Prepare and plant sites and construct windrows along the contour. Do not locate windrows in SMZs or stream channels. Avoid disking on steep slopes and on highly erodible soils. Provide water outlets on bedded or furrowed areas, and discharge water onto vegetated surfaces. Follow approximate contours when ripping.

5. Fire

Do not use high-intensity burns. Install water bars and wing ditches on firebreaks to minimize erosion.

6. Silvicultural Chemicals

All chemicals should be stored, used, and disposed of in accordance with applicable federal, state, and local regulations. Prevent leakage of chemicals during transportation, storage, mixing, or application. Do not use water from private springs, streams, ponds, or wells to mix chemicals. Mix chemicals and clean tanks only where possible spills will not enter surface water. If a spill occurs, construct a dike around the spill, use absorbent material to soak up the liquid, and prevent the spill from flowing into surface water. Immediately notify the Texas Water Commission or Office of Emergency Services.

Plan chemical applications to avoid direct and indirect entry of chemicals into surface waters and the SMZ. Do not aerially apply chemicals where stream pollution can occur through drift, and use a spray device capable of immediate shutoff to stop chemical application during turns and over open water. Use injection or stump treatment herbicide methods in areas immediately adjacent to open waters. Do not apply pesticides to trees or vegetation that exists on eroded slopes, gullies, and drainages, or to any fragile areas subject to erosion.

Clean equipment and containers where chemicals will not enter surface waters. Rinse empty containers and mixing apparatus three times before disposal, and apply rinse water in spray form to the treated area.

7. Streamside Management Zones

Retain an SMZ at least 50 feet wide on each side of perennial watercourses. SMZs may also be desirable on intermittent streams. Locate roads, skid trails, and logging decks outside the SMZ. Restrict management activities causing pollution or erosion. Log mature timber carefully and selectively so as not to destroy the filtering effects of the SMZ. Retain enough trees and understory vegetation in the SMZ to provide adequate protection from solar radiation, impact from erosion, and the placement or washing of debris into the stream. Remove all harvesting debris from the watercourse. If vegetative cover is removed from a stream bank or SMZ, reestablish cover as soon as possible. Do not use fertilizers in the SMZ.

State Contact:

Roger Lord
Forest Resource Development Dept.

VERMONT

Reference: Vermont Department of Forests, Parks, and Recreation. 1987. *Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont*.

Vermont's Water Quality Statutes require permits for discharges of any waste into waters of the state. However, individual permits are not required for logging discharges if acceptable management practices (AMPs) are being applied. The Statutes require that AMPs be implemented. If there is a discharge from forestry activities and neither has a permit been obtained nor have AMPs been implemented, the landowner and logger are liable and subject to enforcement action, penalties, or both. In the following summary, AMPs are in italics. The remaining information is supplementary material that will assist with the implementation of AMPs.

ACCEPTABLE MANAGEMENT PRACTICES AND GUIDELINES

1. Truck Roads
2. Skid Trails
3. Surface Water and Stream Crossings
4. Protective Strips
5. Log Landings

1. Truck Roads

Plan roads to retain adequate filter strips between roads and streams and to locate stream crossings where they will cause the least disturbance. Old roads should be used when acceptably located. Avoid rocky outcrops, ledges, swampy places, and other areas presenting construction problems. Roads should not be constructed on slopes greater

than 10 percent, but *steeper roads may be constructed for distances not exceeding 300 feet*.

Road surfaces should be adequately drained, and runoff should be diverted under or away from the road surface before gaining sufficient velocity to erode ditches. If road grades are greater than 10 percent, culverts may be needed to divert water. Road drainage from grades less than 10 percent where no streams cross the road may be accomplished using broad-based dips. Drainage structures should be installed with a gradient of at least 4 degrees when ledge and rock permit. Tables and figures are provided in the manual with suggested spacing for drainage structures. Culverts should have a minimum diameter of 15 inches. A table in the manual provides culvert sizes and spacing. Drainage ditches shall not terminate where they will deposit water directly into streams or other surface waters. Design ditches to discharge onto undisturbed, vegetative land. Properly stabilize drainage ditches to minimize erosion. All drainage structures should be periodically inspected and maintained.

Bridges and culverts constructed on permanent roads should be left in place and regularly maintained. Bridges and culverts on temporary roads should be removed at the conclusion of harvesting operations, and stream banks should be stabilized.

Upon completion of harvesting operations, water bars should be installed at proper intervals along temporary roads. The specifications for construction are provided, but water bars should be at least 8 inches deep and installed with a 4 degree gradient when ledge and rock permit. Deep water bars should be used on closed roads; back-to-back water bars located at the beginning of closed roads will discourage entrance. Water bars

should divert surface runoff into areas of undisturbed vegetation.

2. Skid Trails

Plan skid trails to retain adequate filter strips between roads and streams and to locate stream crossings where they will cause the least disturbance. Skid trails should be constructed to match the topography of the land and should avoid stream banks, rocky places, and steep grades. *Skid trails shall not be constructed straight up the slope; rather they should proceed at a gradual angle across the slope. Sections of up to 300 feet may be constructed on gradients up to 20 percent.*

Skid trails should be drained using out-sloping turnouts, broad-based dips on grades of less than 10 percent, or pole culverts. Tables in the manual provide the recommended spacing for these structures. Silt fencing, haybale erosion checks, or water diversions shall be used to prevent sediment from skid trails from entering streams or other surface waters. Haybale erosion checks may not be necessary during frozen, stable winter conditions.

After harvesting, ruts in skid trails should be filled and smoothed. Water bars should be installed at proper intervals to divert water from road surfaces into undisturbed litter or vegetation. Construct barriers to prevent off-road vehicles from accessing retired skid roads.

3. Surface Water and Stream Crossings

All logging activities should be kept out of stream channels, except for construction of stream-crossing structures. The construction of stream crossings should be timed to coincide with low water levels and be completed as quickly as possible. All streams should be crossed perpendicular to stream flow. Truck road crossings over permanent streams should

use a bridge or culvert. Bridges should be used whenever possible and should be located where the stream channel is straight with an unobstructed flow. The roadway leading up to a bridge, culvert, or ford should be nearly level for a distance of 50 feet on each side of the stream. Culvert size selection should be based on the drainage area and should be able to accommodate the largest potential stream flows. Streams may be forded by skid trails only where streambeds have stable beds and stable gradual approaches. Streams may also be crossed by brushing-in during frozen winter conditions; all brushed-in material should be removed from the stream channel when skid trail use has been completed or before spring runoff. The turnups of broad-based dips shall be installed on truck or skid roads before they cross a stream. Exposed soil within 25 feet of a stream must be seeded and mulched with mixtures and application rates provided. Streams and all other water bodies should be kept free of slash and other logging debris.

After harvest, all nonpermanent structures must be removed from streams and the channel should be restored to its preharvest condition. Permanent culverts left in streams must be sized according to specifications provided in the guide. Following the close of operation, all approaches to streams, between the stream and the first water diversion of either side, and all disturbed stream banks should be stabilized and seeded and mulched at mixtures and application rates provided. This should be accomplished within 1 year of the completion of logging operations.

4. Protective Strips

Retain a protective strip along streams and all other water bodies in which only light thinning or selection harvesting can occur. Log transport machinery must remain at least 25 feet from a stream or water body. The width of the protective strips are based on the

slope of the land between roads or harvesting activities and the streams. Table 30 presents the required protective strip widths.

Table 30. Protective Strip Widths

Slope (percent)	Protective Strip Width (feet)
0-10	50
11-20	70
21-30	90
31-40*	110

*Add 20 feet for each additional 10 percent side slope

5. Log Landings

Log landings shall be located on level or gently sloping, stable ground. Locate the landings away from low or poorly drained soils. Landings should be no larger than necessary to conduct operations. Landings shall not be located with protective strips. Divert upslope drainage from skid roads away from the landing area. Silt fencing, haybale erosion checks, or water diversions shall be used to prevent sediment from entering streams.

After the completion of harvest activities, log landings shall be graded and water diversions installed. Areas of exposed soil within the protective strip along waterways shall be seeded and mulched according to the specifications provided.

State Contact:

Brian Stone
Dept. of Forests, Parks, and Recreation
103 South Maine Street
Waterbury, VT 05671-0602

or

John Maciejowski
Dept. of Forests, Parks, and Recreation
RR 1, Box 33
North Springfield, VT 05150

Other Available State Information

Manuals/ Books	<i>Wetland Rules and Regulations: What They Mean to Your Logging Operation in Vermont</i>
Videos	<i>Plank Skid-trail Bridge Construction</i>

VIRGINIA

Reference: Virginia Department of Forestry.
1989. *Forestry Best Management Practices for Water Quality in Virginia.*

BEST MANAGEMENT PRACTICES

1. Preharvest Planning
2. Haul Roads
3. Skid Trails
4. Log Decks, Landings and Portable Sawmill Locations
5. Streamside Management Zone
6. Drainage Structures
7. Stream Crossings
8. Site Preparation
9. Revegetation of Bare Soil Areas
10. Wildfire Control and Reclamation

Forested Wetlands

11. Natural Regeneration
12. Preharvest Planning
13. Truck Haul Roads
14. Skid Trails
15. Log Decks
16. Streamside Management Zone
17. Cross Drainages

1. Preharvest Planning

The purpose of preharvest planning is to identify efficient harvest operations and to use appropriate BMPs to maintain water quality. Before harvesting, a plan should be developed that includes the following information: property boundaries, streams and drainages, soil restrictions, slope, environmental concerns, approximate locations of haul roads and skid trail locations, potential log landings, portable sawmill locations, stream or drainage

crossings, and streamside management zones. The timing of harvest should also be included in the plan. A site review should be performed to determine potential road locations, log landings, and streams and wet areas.

2. Haul Roads

All roads should follow the contour as much as possible with the grade ranging from 2 to 10 percent. Gradients exceeding 15 percent may be used for reaches not exceeding 200 feet. Change the grade of the road frequently rather than using long, straight, continuous gradients. On soils with severe erosion potential, grades should be maintained at 8 percent or less, but may exceed 12 percent for reaches less than 150 feet provided measures are taken to prevent erosion. Cross drainage may be necessary to prevent erosion from the steeper roads.

Intermittent or perennial streams should be crossed using bridges, culverts, or rock fords at as close to right angles to the stream channel as possible. Structures should be sized appropriately so that stream flow or fish passage is not disturbed. Water turnouts should be installed prior to stream crossings to divert runoff water into undisturbed areas of the streamside management zones. With the exception of stream crossings, roads should be constructed at least 50 feet from the stream. Fords may be used to cross streams when the stream banks are stable and the stream bottom is hard.

Out-slope roads where gradient and soil type permit. In-slope the road toward banks on sharp turns, on roads with gradients exceeding 15 percent, and on clay or slippery soils. Use cross drainage on in-sloped or crowned roads to limit the travel distance of runoff water; broad-based or rolling dips should be used on

in-sloped or crowned roads when gradients begin to exceed 2 percent for more than 200 feet. Gravel, wooden mats, or other means should be used to prevent mud from being carried from haul roads. Single-track roads should have a minimum width of 10 feet; increase the width as necessary on curves and turnouts. Vertical road banks should not exceed 5 feet in height; cuts more than 5 feet should be sloped to at least a 2:1 ratio and seeded. Install rip-rap at the outlets of culverts and dips to adsorb and spread waters. Cut trees alongside roads to allow sunlight to ensure drying of the road.

To maintain haul roads, traffic should be restricted from haul roads during unfavorable conditions such as wet soil. Haul only during dry weather on wet soils, erodible soils, or road gradients exceeding 10 percent that do not have erosion protection. Roads should be kept free of debris and ruts to allow water to drain from the road surface. Regrade roads when the average rut depth exceeds 6 inches over a distance of greater than 50 feet. When all harvest activities are completed, the road should be reshaped. Ensure that drainage systems are open, and seed all bare soil greater than or equal to 5 percent slope or subject to erosion along the access roads, main skid trails, and log landings.

3. Skid Trails

Log landings should be located prior to laying out road approaches. Gradients on skid trails should be no steeper than 15 percent, except where required to avoid boundary lines, sensitive areas, or other areas not accessible. Skid trails must be located outside SMZs. Where stream crossings are needed, culverts should be used. Any skid trail that must cross a perennial or intermittent stream should use a bridge or culvert of acceptable design. Logs should not be skidded through perennial or intermittent streams. Approaches to water

crossings should be at as near to right angles to the stream channel as possible. Skid roads should climb up-slope on a slant or zig-zag pattern. Upon completion of skidding, water bars should be installed immediately. The intervals for water bars are presented in Table 31.

Table 31. Water Bar Intervals

Slope (percent)	Distance (feet)
2	250
5	135
10	80
15	60
20	45
30	35

Water bars should be installed at a 30 to 45 degree angle downslope, with ends open to prevent water accumulation behind them. A permanent vegetative cover should be established on exposed roads, trails, and landings that are greater than or equal to 5 percent slope or subject to erosion.

4. Log Decks, Landings, and Portable Sawmill Locations

Locate sites for log decks and portable sawmills prior to road construction. Decks and portable sawmill sites should be located at least 50 feet outside the SMZ and should be on well-drained soils with a slope of 2 to 5 percent to enhance drainage. Provide for adequate drainage on approach roads and skid trails, such as a diversion ditch around the uphill side of a deck to intercept water flow and direct it away from the deck. Locate residue piles outside wet weather drainages. When servicing equipment, properly drain waste products into containers and dispose of them in accordance with proper solid waste

disposal procedures. Remove garbage and trash and dispose of them properly. Decks, landings, and portable sawmill locations should be stabilized to prevent erosion and sediment loss within the first 15 days of the next seeding season following completion of harvesting operations.

5. Streamside Management Zone

Streamside management zones should have a minimum width of 50 feet on both sides of perennial streams and around open water bodies. SMZs may be desirable on intermittent streams for large drainage areas where wildlife or water quality is a major landowner concern. The recommended SMZ widths for various water bodies are presented in Table 32.

Partial harvesting of the SMZ is acceptable, but a minimum of 50 percent crown cover or 50 square feet of basal area per acre must be evenly retained. Limit the use of logging equipment by using dispersed skidding, cable and winch, and similar methods. The forest floor should remain essentially undisturbed, and mineral soil should not be exposed. Locate sawmill sites and decks outside the SMZ. Remove all harvested tree limbs and tops from the stream.

Access roads should cross perennial or intermittent streams at or near a right angle;

access roads should be kept to a minimum within the SMZ. Stabilize all roads, cuts, and fills in the SMZ within the first 15 days of the next seeding season. Fertilizer should not be used in SMZs. Install energy absorbers at cross-drained culvert outlets or other discharge points. Ditches, cross-drain culverts, water bars, rolling dips, and broad-based dips should be used on all roads prior to their entrance into an SMZ.

6. Drainage Structures

Broad-based dips can be used on truck haul roads and heavily used skid trails that have a gradient of 12 percent or less to provide cross drainage. They should not be used for cross-draining spring seeps, intermittent streams, or perennial streams. They should be installed during road construction following the basic clearing and grading phase. The spacing of broad-based dips should be determined by the following formula:

$$\text{Spacing (feet)} = \frac{400}{\text{slope \%}} + 100$$

Install an energy absorber, such as rip-rap, at the outfall of the dip to dissipate water velocity and minimize erosion potential. Surfacing the dip with 3-inch crushed stone may be desirable to prevent rutting.

Table 32. Recommended SMZ Widths for Various Waters

Water Type	Slope of Adjacent Lands			
	0-10	11-20	21-45	45+
Cold-Water Fisheries (trout)	66	75	100	125
Warm-Water Fisheries	50	50	50	50
Municipal Water Supplies	100	150	150	200

Rolling dips can be used on truck haul roads and heavily used skid trails that have a gradient of 15 percent or less to provide cross drainage. They should not be used for cross-draining spring seeps, intermittent streams, or perennial streams. Install rolling dips on roads during construction following the basic clearing and grading phase or on skid trails after logging is completed. Recommended spacing is provided in the manual.

Water bars should be used on roads and skid trails that will not have vehicular traffic. If there is the potential for vehicular traffic, use rolling dips. Water bars should be constructed at an angle of 30 to 45 degrees downslope with the uphill end of the bar extending beyond the side ditch. The outflow end of the bar should disperse runoff water onto undisturbed forest floor. Recommended spacing is provided in the manual.

Pipe culverts or open-top box culverts can be used for any size operation where cross drainage of storm water is needed on truck haul roads or major skid trails. Pipe culverts should be installed on a 2 to 4 percent grade, skewed 15 to 30 degrees downgrade, and should be long enough so both ends extend at least 1 foot beyond the side slope of fill material. Box culverts should be installed flush or just below the road surface and skewed 15 to 30 degrees downgrade. Spacing of culverts can be determined using the formula for broad-based dip spacing. The culvert outfall should be protected to dissipate water velocity and minimize erosion potential. The structure should be maintained by removing sediment, gravel, or logging debris.

7. Stream Crossings

When streams must be crossed by logging equipment, use bridges, culverts, or rock fords. Bridges should be constructed with minimum disturbance to the stream bank,

channel, or adjacent SMZ. Pipe culverts should be installed on a 2 to 4 percent grade and should be long enough so both ends extend at least 1 foot beyond the edge of the fill material. Recommended culverts sizes are based on the acres drained, soil density, and slope. Erosion protection measures should be installed at the culvert outlet to minimize downslope erosion. Recommended culvert sizes are provided in the manual. Rock fords or log fords may be used if no practical alternative exists, but the approaches and stream bottoms must be hard enough so turbid water does not result.

8. Site Preparation

A Forest Management Plan should be prepared prior to any site preparation. This plan will consider the condition of the tract, landowner desires, adjacent property, environmental concerns, and water quality. Site preparation activities should not be conducted in SMZs.

Prescribed burning should be conducted when soil moisture or weather conditions are sufficient to prevent removal of all surface duff and root mat. Construct firelines around the perimeter of the burn area and along the perimeter of the SMZ, and install water bars and turnouts. Drainage from firelines should be diverted away from streams.

Mechanical site preparation should be conducted in a manner that minimizes erosion and water quality impacts. Schedule operations during favorable soil moisture and weather conditions. Drum-chop up and down the slope so the depressions created by the cleats and chopper blades are on the contour, reducing the potential for channeled flow. Avoid exposing excess mineral soil during chopping. Disking should be performed on the contour and on slopes of less than 10 percent. When bulldozing, if a potential for erosion exists, leave the topsoil and root mat

in place to preserve site quality and minimize water quality impact. Bulldozing should be limited to slopes of 20 percent or less, and a windrow should be constructed approximately every 200 feet. Windrows should be constructed along the contour, with a 20-foot opening for each 300 feet of windrow. Bedding should be performed along the contour if slope is discernible. Machine planting, subsoiling, and sod scalping should be performed on the contour, and steep slopes should be hand planted.

Application of pesticides and disposal of containers should follow manufacturer's label instructions, and measures should be implemented to prevent pesticides from reaching surface waters by direct application or runoff. Application of fertilizers and disposal of containers must adhere to manufacturer's label instructions. Application rates of fertilizers should be based on soil analysis and developmental needs of the desired tree species. Broadcast application of fertilizers within 50 feet of open water is not recommended.

9. Revegetation of Bare Soil Areas

All disturbed areas with a grade of 5 percent or greater must be seeded and mulched within the first 15 days of the next seeding season. Upon completion of operations, bare soil areas with grades greater than 5 percent and/or areas of bare soil with erosion potential (landings, sawmill locations, skid trails, or haul roads) should be identified for revegetation as the season permits. Lime and fertilizer application rates should be determined by soil type and acidity. Suggested seeding mixtures, rates, and dates are provided. Mulch should be applied immediately after seeding highly erodible slopes or during adverse soil or weather conditions. Seeded areas should be protected from grazing and unrestricted vehicle use.

10. Wildfire Control and Reclamation

When possible, do not plow firelines directly into SMZs. If this is unavoidable, revegetate as soon as possible. Stabilize and revegetate firelines on grades greater than 5 percent. Bare soil should be revegetated and eroding gullies treated. Where timber has been killed, reforestation needs should be assessed.

Forested Wetlands

There may be restrictions on some silvicultural activities dependent upon legal interpretations of wetlands and the conversion from wetland species to other species. Discharge of fill materials into waters of the United States from ditching or from other activities whose purpose is to convert forested wetlands to some other use, or where the flow or circulation of the waters may be impaired or the reach reduced, is not permitted under the silvicultural exemptions under the Clean Water Act.

11. Natural Regeneration

Successful regeneration depends on: (1) recognizing the site type and its characteristics; (2) evaluating the stocking and species composition in relation to stand age and site capability; (3) planning regeneration options; and (4) using sound harvesting methods. Natural hardwood regeneration uses the normal cycle of wetlands species succession. The harvesting system, which also serves as the regeneration system, must be chosen on the basis of stand and site conditions and landowner objectives. Schedule harvest during the dormant season to take advantage of seed crops and to favor coppice regeneration. Harvest the stand as completely as possible to allow maximum sunlight, and leave stumps at a height of less than 10 inches. Minimize soil degradation from logging and site preparation, especially during saturated soil conditions. Following a clearcut (where ground conditions

permit), control residuals larger than 1.5 inches in diameter by felling, girdling, stump treatment, or injection of chemical herbicides.

12. Preharvest Planning

Preharvest planning provides an organized method for an efficient harvest operation while maintaining subsurface and surface water quality. The wetlands preharvest plan should include:

- upland preharvest planning considerations;
- establishment of 50-foot-wide SMZs on each side of the main channel or areas of open water;
- location of log decks and main sources of road-building materials;
- identification of main road system on the uplands and development of a tentative road system within the wetlands;
- identification of special equipment required for skidding and hauling or other harvesting methods; and
- identification of potential problems or events that may interrupt logging operations.

Schedule harvesting operations during extreme dry periods or during times that enhance regeneration. Use machinery with adequate flotation devices to minimize the impact on the soil surface or degradation of site quality.

13. Truck Haul Roads

Construct road fill only when absolutely necessary. Road fills should be no more than 2 feet above the natural ground level and should be constructed parallel to the flow of the main channel at least 200 feet from the SMZ. Provide cross drains at a minimum

every 100 feet. Use gravel or crushed rock as fill to provide for movement of ground water and to serve as a base for the road. A layer of poles, slabs, or logs laid side-by-side, extending 3-4 feet on each side beyond the width of the roadbed, can provide a base for borrow or fill material. Thick layers of large wood chips can be used as a roadbed to distribute load weight and limit the road's adverse impact. Use planking or wooden mats to improve the soil's ability to support traffic of heavy loads. Cross streams, sloughs, or existing drainage channels with properly sized culverts or bridges.

The use of oversized or balloon tires is encouraged to reduce compaction and rutting. Move equipment to the uplands during periods of potential flooding and wet periods. Upon completion of harvesting operations, remove temporary drainage structures and obstructions from channels, stabilize roads to prevent erosion and sediment loss, and restrict access.

14. Skid Trails

Plan major skid trails to minimize damage to the residual stand, reduce erosion and sedimentation, maintain surface and subsurface water flow, and provide the most economical method for skidding products. Locate skid trails outside SMZs and after the location of log decks has been decided. Use sandy sloughs as skid trails when harvesting in peat and muck swamps. Avoid stream crossings unless absolutely necessary, but use a bridge or culvert of acceptable design when a stream crossing is unavoidable. Approaches to water crossings should be at or near a right angle to the stream flow and of sufficient length to allow logs to line up behind the skidder. The use of wide-tracked bulldozers and flotation tires on skidders is recommended.

15. Log Decks

Locate log decks in advance of road construction, and on elevated lands of the uplands or higher elevations within large wetland units. Provide for adequate drainage on approach roads and skid trails. Use gravel, borrow materials, slab materials, mats, fabrics, or other material to provide adequate drainage and bearing capacity. Locate residue piles outside the wetlands or wet weather drainages. Service equipment in such a way that petroleum products and toxics are contained and properly disposed of. Garbage, trash, and inoperable equipment should be removed at the end of harvesting operations. Stabilize landings within the first 15 days of the next seeding season after completion of the harvest. Locate mill seats and log decks on uplands more than 50 feet from SMZs.

16. Streamside Management Zone

The practices recommended for SMZs in wetlands are essentially the same as SMZs in upland areas. The use of a grapple skidder is recommended to create less disturbance of the forest floor. Minimize the number of access roads through the SMZ, and stabilize all roads, cuts, and fills in the SMZ.

17. Cross Drainages

Cross drainages can be used for any size operation where drainage is necessary to reduce ponding. The pipe diameter should be a minimum of 15 inches. Recommended pipe/culvert sizes are provided in the manual and are based on acres drained and soil type. Multiple pipes may be used to meet the minimum required diameter. The pipe slope should be just below the streambed gradient with pipe alignment parallel to the stream course. The pipe length should be long enough so both ends extend a minimum of

1 foot beyond the side slope of the roadbed, and erosion protection should be provided at pipe outfalls.

State Contact:

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or

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Other Available State Information

Brochures	<i>Forest Landowner and Water Quality; Debris in Stream Law; Landowners, Loggers, Foresters Use BMPs</i>
Videos	<i>Managing Mountain Forests for Clean Water; Impact of BMP Regulations on Maryland Logging; BMPs for Logging</i>

WASHINGTON

Reference: Washington State Forest Practices Board and Department of Ecology. 1992. *Washington Forest Practices Rules and Regulations*.

Washington has designated five water categories determined by water usage and water quality. Washington has also designated four classes of forest practices and three wetland types. The Department of Natural Resources must approve notification before implementing Class II forest practices. Implementing Class III or IV forest practices requires an approved application. In addition to the rules and regulations summarized below, the Washington State Forest Practices Board has published a *Forest Practices Manual* that includes methods for determining adequate shade on streams and for measuring stream channel width, gradient, and flow; a chart for determining permanent culvert sizes; guidelines for clearing slash and debris from Type 4 and 5 Waters, landing location and construction, determining acceptable stocking levels, calculating average widths of riparian management zones (RMZs), wetland delineation, and wetland replacement by substitution or enhancement; a list of non-native wetland plant species; a list of special concerns related to aerial application of pesticides; and a methodology for conducting watershed analysis.

BEST MANAGEMENT PRACTICES

1. Watershed Analysis
2. Wetlands
3. Road Construction and Maintenance
4. Timber Harvesting
5. Reforestation
6. Forest Chemicals

1. Watershed Analysis

Watershed analysis is designed to assess selected biological and physical parameters of the environment within a watershed administration unit (WAU) and to provide information needed to regulate cumulative effects of forest practices on fish, water, and capital improvements of the state and its political subdivisions. Level 1 Assessments are low-intensity evaluations of a WAU to identify areas of resource sensitivity and to determine whether a more intensive Level 2 Assessment is needed. Prescriptions are developed for identified areas of resource sensitivity. Site-specific conditioning of silvicultural activities by prescriptions preempt the regulations that would otherwise apply.

2. Wetlands

Wetlands are designated as Type A or B or forested. Type A Wetlands are nonforested wetlands that are at least 0.5 acre (0.25 acre if bog or fen) with ponded or open water that is present for 7 consecutive days April 1 to October 1. Type B Wetlands are all other nonforested wetlands that are at least 0.25 acre. Forested wetlands are those that have a 30 percent or greater crown cover or would have 30 percent crown cover if the trees were mature. The Board Manual has approved guidelines for wetland delineation and replacement by substitution or enhancement

and a list of non-native wetland plant species that must not be introduced. Western and Eastern Washington have wetland management zones (WMZs) for Type A and B wetlands and their bogs and fens. WMZs are required on bogs and fens 0.25 acre and larger and on other wetlands 0.5 acre and larger. WMZs have variable widths based on the size of the wetland and wetland type and range from a maximum width of 200 feet to a minimum width of 25 feet. The protection of wetlands is addressed in the following sections of this summary.

3. Road Construction and Maintenance

Fit the road to the topography, and avoid locating roads along or within narrow canyons, RMZs, wetlands, and WMZs, or on excessively steep or unstable slopes, or known slide-prone areas. Do not locate roads in wetlands where there will be substantial loss of wetland functions or acreage unless alternatives are more damaging to public resources. Minimize the number of stream crossings, and cross streams at right angles. Use existing roads whenever practical, and avoid isolating patches of timber that may require unnecessary road construction for removal later.

Use the minimum design standard to produce a road capable of accommodating the anticipated traffic load. The subgrade width should not average more than 32 feet for double-lane roads and 20 feet for single-lane roads. Balance excavation and embankments. Design or construct cut-and-fill slopes not to exceed the normal angle of repose for the materials involved. All roads must have adequate drainage through use of cross drains, ditches, drivable dips, relief culverts, water bars, diversion ditches, or other such structures. Cross drains are required in wetlands to provide continued hydrologic connectivity. Cross drains, relief culverts and diversion

ditches must not discharge onto erodible soils or over fill slopes. Relief culverts must be at least 15 inches in diameter and must be installed sloping toward the outside edge of the road at a minimum gradient of 3 percent. Where roadside ditches slope toward a Type 1, 2, or 3 Water or a Type A or B Wetland for more than 300 feet and otherwise would discharge into the stream, divert the ditch water onto the forest floor at the first practical point. Filling or draining more than 0.5 acre of wetland requires replacement by substitution or enhancement of the lost wetland functions and area.

Construct roads when moisture and soil conditions are not likely to result in excessive erosion or soil movement. Do not bury loose stumps, logs, or chunks containing more than 5 cubic feet in the load-bearing portion of the road, any significant amount of organic debris within the top 2 feet of the load-bearing portion of the road, or any excessive accumulation of debris or slash in any part of the load-bearing portion of the road fill. Stabilize exposed soil areas by seeding with grass, clover, or other ground cover. Avoid the introduction of non-native plant species to wetlands and WMZs. Clear the stream channel of all debris and slash generated. Install all required drainage devices concurrently with the construction of the roadway. End haul or overhaul construction is required where significant amounts of sidecast material would rest below the 50-year flood level of a Type 1, 2, 3, or 4 Water, or within Type A or B Wetlands or WMZs. No spoils area greater than 0.5 acre may be placed in typed wetlands or their management zones.

Locate landings to prevent damage to public resources, and where excessive excavation and filling will not be necessary. Do not locate landings within typed wetlands or their WMZs. Slope landings to minimize the accumulation of water. Out-slope or cross

drain truck roads, skid trails, and fire trails that are uphill of landings, and divert water onto the forest floor away from the toe of any landing fill. Landings requiring sidecast or fill must be no larger than reasonably necessary. Where average general slopes exceed 65 percent, fill material used in constructing landings must be free from loose stumps and excessive slash and must be mechanically compacted.

Bridges are required for new crossings of any Type 1 or 2 Waters regularly used for recreational boating. Permanent bridges must not constrict clearly defined channels. All permanent bridges and culverts must be designed to pass the 50-year flood level, or the road must be constructed to provide erosion protection from the 50-year flood waters exceeding the capacity of the drainage structure. One end of each new permanent log or wood bridge must be tied or firmly anchored if the bridge is within 10 vertical feet of the 50-year flood level. Culvert alignment and slope must parallel the natural flow of the stream, and the culvert must be terminated on materials that will not readily erode. Clear streambeds for a distance of 50 feet upstream from the culvert inlet of all slash and debris. In streams used by anadromous fish, culverts must either be open bottomed or have the bottom covered with gravel and installed at least 6 inches below the natural stream bed at the inlet and outlet, and closed bottom culverts must not slope more than 0.5 percent. The rules provide minimum culvert sizing for stream and wetland crossings that are based on the presence of anadromous fish, game fish, or no fish. Temporary bridges and culverts adequate to carry the highest anticipated flow in lieu of carrying the 50-year flood may be used if installed after June 1 and removed by September 30 of the same year. Temporary bridges and culverts must be promptly removed upon completion of use, and approaches to crossings must be water barred

and stabilized. Temporary wetland crossings must be approved, abandoned, and restored according to prior written plan.

A plan for road maintenance and abandonment of drainages or road systems should be determined by the Department of Natural Resources. For active roads, culverts and ditches must be kept functional, road surfaces must be maintained to minimize erosion, and road surfaces must be crowned, out-sloped, or water barred and berms removed from the outside edge. For inactive roads, nonfunctional ditches and culverts must be cleared and/or repaired and the road surface crowned, out-sloped, or water barred. Abandoned roads should be out-sloped, water barred, or otherwise left in a condition suitable to control erosion and maintain water movement within wetlands. Bridges, culverts, and fills on all waters should be removed, and access to the road should be blocked.

Locate rock quarries and gravel pits above the 50-year flood level. Locate spoil disposal areas above the 50-year flood level, on areas of low potential timber productivity, where the final slope will be no steeper than 1½:1, where the risk of erosion and mass soil movement is minimal, and outside typed wetlands and their management zones. During the construction and use of rock quarries, borrow pits, or gravel pits, runoff must be diverted either onto the forest floor or into settling basins. These areas must be rehabilitated within 2 years of their abandonment. Rehabilitation includes removal of all deleterious material, grading to less than the angle of repose, and reforestation or revegetation.

4. Timber Harvesting

Riparian management zones must be measured horizontally from the ordinary high water mark of Type 1, 2, or 3 waters and must

extend to the line where vegetation changes from wetland to upland plant community or to the line required to leave sufficient shade. Leave trees in the RMZs for wildlife and fisheries habitat management. Fifty percent or more of the trees must be live and undamaged on completion of harvest. The specifications for width and leave tree requirements are different in western RMZs and eastern RMZs and are provided in the rules and regulations. RMZ widths may be extended to the maximum width to provide sufficient shade to protect stream temperature and farther, if needed, to include wetlands. Where overlapped by WMZs, the leave tree provisions that best protect public resources are to be used.

When harvesting in RMZs along Type 1, 2, and 3 Waters, avoid disturbing understory vegetation, root systems, and any logs embedded in the bank. Leave high stumps where necessary to prevent felled or bucked timber from entering the water. Minimize the number of skidding routes through the RMZ. The temperature prediction method described in the *Forest Practices Manual* should be used to determine the minimum shade cover necessary to prevent excessive water temperatures, which may have a detrimental impact on aquatic resources, for flowing Type 1, 2, and 3 Waters. The method uses site-specific characteristics and includes consideration of shade retention, minimum leave tree requirements, regional water temperature characteristics, elevation, and temperature criteria defined for stream classes in Department of Ecology water quality standards. A temperature prediction model is available from the Department of Natural Resources.

When harvesting wetland management zones, leave 75 trees per acre greater than 6 inches dbh in western Washington and greater than 4 inches dbh in eastern Washington. Leave trees should be representative of the species found

within the WMZ. Openings created by harvesting within the WMZ may not exceed 100 feet as measured parallel to the wetland edge and may be no closer than 200 feet. Do not use tractors, wheeled skidders, or other ground-based harvesting systems within the minimum WMZ width. If individual trees or forested wetlands of less than 0.5 acre occur within the boundaries of nonforested wetlands, do not harvest. Do not fell timber into or yard timber across Type A or B Wetlands without written approval of the Department.

Harvesting methods within forested wetlands are limited to low-impact harvest or cable systems, and at least one end of the log should be suspended during yarding. Clump leave tree areas adjacent to streams, RMZs, or WMZs. Green recruitment trees should be representative of the size and species found within the wetlands. No point within the harvest unit may be more than 1,000 feet from a wildlife reserve tree and green recruitment tree retention area.

Even-aged harvests of more than 240 contiguous acres or more than 40 contiguous acres on saltwater islands is prohibited. Do not fell trees into Type 1, 2, and 3 waters or Type A and B Wetlands. Use directional felling and skid trees away from water. Do not cable yard timber in or across Type 1, 2, or 3 Waters, except where logs will not materially damage the area. Yard in an uphill direction. Do not remove or disturb any logs firmly embedded in the bottom of a stream. Do not use tractors or wheeled skidders in Type 1, 2 or 3 Waters, and minimize skidding across flowing Type 4 Waters. Minimize skid trail width, and out-slope where practical.

Upon completion of harvest operations, landings must be cleaned up and stabilized. Clear obstructions from ditches and culverts. Regrade to prevent accumulation of water, and ensure that all cut slopes are stable.

Revegetate, mulch, and water bar as necessary. All cables, machine parts, and other inorganic debris must be removed.

Any conventional method of slash disposal is allowable, except in wetlands and WMZs; burning and scarification are prohibited, and machine pulling is discouraged. Do not pile or windrow slash below the 50-year flood level of any Type 1, 2, 3, or 4 Water or in locations from which it could be expected to enter any watercourse or waterbody. When burning, fire trails should be constructed with dips, water bars, cross drains, and ditches as necessary to control erosion. Do not locate fire trails within Type A or B Wetlands or WMZs without prior written approval of the Department.

5. Reforestation

Reforestation requirements and stocking levels vary by region and are specified in the rules and regulations. Reforestation plans must be submitted with the application or notification. Do not use heavy equipment for site preparation or rehabilitation if soil moisture conditions or soil type would cause undue compaction or damage to soil productivity or would generate erosion. Do not operate heavy equipment in RMZs, Type A or B Wetlands, WMZs, within 10 feet of the ordinary high water mark of Type 4 and 5 Waters on slopes 30 percent or less, or within 50 feet of any waters on slopes greater than 30 percent.

6. Forest Chemicals

Transportation, handling, storage, loading, application, and disposal of pesticides must conform to label requirements and state and federal regulations. Prevent pesticide leakage, contamination, and pollution. Store and mix chemicals and clean tanks and equipment where any accidental spill would not enter surface waters or wetlands. If any chemical is

spilled, immediately take appropriate procedures to neutralize it. Provide an air gap or reservoir between the water source and the mixing tank. Chemical treatments in RMZs and WMZs must be applied by hand or by an approved specific alternative. For aerial pesticide applications, leave a 50-foot buffer strip around all waters and do not allow pesticides to directly enter waters, typed wetlands, or riparian or wetland management zones. Aerial application of fertilizers requires a 25-foot buffer on all Type 1, 2, and 3 Waters. During ground pesticide treatments with powered equipment, leave a 25-foot buffer around all waters and typed wetlands. Chemical containers must be removed from the forest and either disposed of according to label instructions or cleaned for reuse according to applicable regulations of the state agriculture department or state and local health departments.

State Contact:

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(206) 902-1410

Other Available State Information

Manuals/ *Board Manual and Guidelines;*
Books *Forest Practices Act*

Brochures *Fact Sheets and Heads-Up*
describe changes to the Forest
Practice Rules and provide a
general summary of new rules;
Monitoring Guidelines to
Evaluate Effects of Forestry
Activities on Streams in the
Pacific Northwest and Alaska

Videos *Wall-based Channels* describes
fish habitat off main channels

WEST VIRGINIA

References: West Virginia Forestry Division. *Clean Streams Handbook for Loggers — Keeping Mud Out of the Streams*; the Logging Sediment Control Act (Article 1B of Chapter 19 of West Virginia Code 1931).

The Logging Sediment Control Act requires that anyone conducting timbering operations, purchasing timber, or buying logs for resale must obtain a license. In addition, timber operators must notify the Division of Forestry within 3 days of the commencement of harvesting operations. The notification must include the following:

- (1) the specific topographic location where the operation will be conducted;
- (2) the approximate dates that the operation will begin and end;
- (3) the approximate acreage of the harvest;
- (4) the name and address of the timber owner(s) and, if different, the name and address of the landowner(s);
- (5) a sketch map of the proposed location, including haul roads, landings, and stream crossings;
- (6) a description of the sediment control practices to be implemented;
- (7) an acknowledgment that the operator will conduct operations in compliance with the Act;
- (8) the name and timbering license number of the person or firm supervising the logging site; and
- (9) the name and certification number of the person(s) supervising the operation.

The Act also stipulates that any individual supervising any timber operation must be certified by July 2, 1993. The certification program provides for education and training in safety, first aid procedures, and the use of BMPs.

BEST MANAGEMENT PRACTICES

1. Planning the Operation
2. Filter Strips
3. Constructing Logging Roads and Landings
4. Maintaining Logging Roads and Landings
5. Retiring Logging Roads and Landings

1. Planning the Operation

Plan the road system to fit the topography. Locate landings first, and plan skid roads to approach at low grades. Space skid roads as far apart as practical. Consider the aspect of the hillside when planning road location; south- and west-facing slopes are usually drier and provide a better location for main haul roads. Avoid locating roads on cliffs, flat ridgetops, easily eroded soils, seeps, swampy places, and other obstacles. Do not locate roads in filter strips.

Examine the distribution and volume of timber to be removed and estimate the number of loads that will be hauled over the road to determine the design and standards to which the various sections and spurs need to be constructed. Design roads to have low grades. Haul roads should be between 3 and 10 percent; grades up to 15 percent are allowable for 200-foot intervals if special treatment is provided to control erosion. Skid roads may be up to 15 percent, but grades up to 20 percent are allowable for short segments. Avoid roads with long, straight grades. Install broad-based dips, grade breaks, or other drainage structures on main haul roads. Design road curves to have a minimum 35-foot radius and nearly level grade.

Plan the harvest on paper. Draw proposed haul and skid roads and landings on a topographic map. Mark proposed drainage or water control structures, such as bridges, culverts, dips, outsloped or insloped roads, grade breaks, and critical areas to be graveled. Prior to construction, walk and flag all proposed road and drainage structure locations to ensure that the roads have been properly placed.

2. Filter Strips

Retain a filter strip with a minimum width of 25 feet between roads and watercourses; however, on watersheds draining more than 100 acres, a width of 25 to at least 200 feet is preferable. The width of the strip should increase as the slope adjacent to the watercourse increases. Harvesting in the strip is allowed, but a shade strip should be retained immediately adjacent to the watercourse to maintain uniform water temperature levels. Do not disturb the soil in filter strips except when needed for stream crossings. Cross streams perpendicular to stream flow using small bridges or culverts. Consider alternative road locations before deciding that a bridge is necessary to transport timber out of a certain tract. Drain runoff from approach roads and divert it away from the streams. Do not skid logs through flowing streams, and never operate the skidder in a stream.

3. Constructing Logging Roads and Landings

Construct roads in the planned locations. Use the narrowest width to safely handle anticipated traffic volume. Maintain temporary water bars and turnouts during construction. If possible, allow newly constructed roads to settle several months before using. Clear the rights-of-ways and daylight the roads to allow for maximum sunlight penetration and drying ability.

Logging roads entering onto paved roads should be covered with heavy gravel for about 200 feet to reduce the amount of mud carried onto the highway.

Install drainage structures on roads and landings. Use natural cross drainage. Out-slope the entire width of the road toward the fill bank to provide good surface drainage. The out-slope grade should be $\frac{1}{4}$ - $\frac{3}{8}$ inch per foot. If road conditions preclude out-sloping, in-slope the road and install ditch relief culverts or drainage dips. Culverts should be spaced 200 to 300 feet apart, should be installed on an 8 to 10 percent grade, and should cross the road at about a 30-degree angle. Use broad-based dips on active haul roads and water bars on retired roads. A diagram is provided in the manual with specifications for proper broad-based dip construction. Discharge drainage dip outflow onto vegetated areas, and install energy dissipators at dip outlets if necessary to reduce erosion.

Stream crossings should be perpendicular to the channel and should not impede stream flow. Use bridges to cross streams that are too big for culverts. A bridge should not be constructed if a culvert or ford can be used to cross the stream. Install culverts on a 2 to 4 percent grade to facilitate drainage. Size culverts to accommodate anticipated high stream flows. Approaches to stream crossings should be surfaced with gravel to reduce siltation of the stream.

Construct landings on dry ground at least 25 feet from watercourses; 100 feet or greater is preferable. If a landing must be located closer to a watercourse than 25 feet, several sediment control measures must be applied. Slightly slope the landing surface to facilitate drainage. Prevent runoff from entering the landing area by providing adequate drainage of

approach roads and constructing a diversion ditch along the uphill side of the landing.

4. Maintaining Logging Roads and Landings

During the logging operation, roads, ditches, dips, and culverts should be maintained to perform properly. Regrade the road surface periodically to remove ruts, and inspect and clean all water control and drainage structures. Restrict traffic during unfavorable weather. Do not allow skidding on haul roads. Do not push logging debris from roads or landings into or toward watercourses. Remove and properly dispose of all trash, used oil, etc.

5. Retiring Logging Roads and Landings

Retire logging roads as soon as they are not needed for removing timber. Do not wait until the entire operation has been completed. Smooth and grade landings and main haul roads. Remove temporary drainage structures and clean permanent drainage structures. Revegetate all exposed soil areas using seed, lime, fertilizer, and mulch. Restrict vehicular access with a gate or deep trench. Plan for future maintenance of permanent drainage control structures. Install water bars on skid trails at the recommended intervals, and leave loped slash and other logging debris on the skid trail to help minimize erosion.

Other Available State Information

Manuals/ Books	<i>Clean Streams Handbook for Landowners; Guidelines for Controlling Soil Erosion and Water Pollution on Logging Operations - a technical pocket guide; Silvicultural Water Quality Management Plan</i>
Brochures	<i>Keeping Mud Out of the Streams; Forest Owners and Logging Roads</i>
Videos	<i>Building Roads; Selling Timber; Forest and Water</i>

State Contact:

William H. Gillespie
Forestry Division
(304) 558-3446

WISCONSIN

Reference: Wisconsin Department of Natural Resources, Bureau of Forestry, and Wisconsin Paper Council. 1990. *Forest Practice Guidelines for Wisconsin*.

BEST MANAGEMENT PRACTICES

1. Forest Management Plans
2. Forest Accessways
3. Timber Harvesting
4. Reforestation
5. Integrated Pest Management

1. Forest Management Plans

Management plans should include a "Statement of Goals" the landowner or manager wants to achieve, an "Inventory" of the timber and other property values, and a "Plan of Action" that outlines how, where, and when the landowner's goals will be met. Soil surveys, topographic maps, aerial photos, and other reference materials should be used as planning tools. Establish harvest boundaries using topographic features such as permanent streams, ridges, roads, and forest type in conjunction with land management goals, available equipment, and silvicultural needs. Schedule activities to minimize potential negative impacts on soils and waters.

2. Forest Accessways

Plan and implement logging road construction and other forest alterations to conserve soil and protect water quality. Minimize surface disturbance during road, skid trail, and landing construction. Grade roads to 8 percent or less for normal soils and to less than 5 percent for erodible soils. Avoid constructing steep cuts

and fills. Do not use surface debris as fill material, and prevent its entry into springs, streams, and lakes. Limit construction during adverse weather.

Divert water off the road surface using ditches, cross drains, drainage dips, and proper water diversion techniques. A permit may be required if drainage structures are within 500 feet of a stream or lake. Minimize stream crossings, and contact regulatory agencies regarding specific rules and permit requirements. Use proper culverts or bridges and adequate amounts of fill and gravel to ensure good drainage. Adequately size culverts and bridges to accommodate stream flows. Avoid fording unless streambeds and banks are sufficiently stable. Minimize disturbance when constructing bridges or installing culverts, and stabilize stream banks when construction is complete. Retain protective strips or buffers adjacent to streams or lakes. Upon completion of operations, remove all stream crossing structures or materials.

Maintain forest accessways by removing debris from culverts and ditches and revegetating skid trails, landings, and unused roads. Grade and/or gravel permanent roads to maintain drainage, and restrict access during wet seasons.

3. Timber Harvesting

Landings should be located and sized to minimize adverse impacts of skidding on the natural water drainage patterns. Locate landings on firm, well-drained ground outside streamside management zones of perennial streams and above the ordinary high water mark of intermittent streams. Landings should use natural topography for drainage. Divert runoff from approach roads to prevent its entry onto the landing. Prevent chemical spills on landings and other intensive work areas. Upon

completion of operations, drain any impounded water on or around the landing and seed landings with a herbaceous cover crop to stabilize erodible soils.

Skidding operations should match equipment with terrain, soils, and weather conditions to minimize soil compaction and other disturbances. Locate skid trails to minimize soil displacement, to use the topography, and to avoid steep gradients and disruption of natural drainages. Skid trails on slopes should have occasional breaks. Minimize the number of skid routes through SMZs, and use culverts, logs, or portable bridges as temporary stream crossings. Rock fords or log fords may be used if a practical alternative to crossing streams does not exist and if the stream approach and stream bottom are hard enough that sedimentation or muddy water does not result. Upon completion of operations, promptly remove all stream crossings, revegetate skid trails, and install water bars.

Carefully fell trees to reduce damage to residual stands and minimize erosion. Directionally fell trees away from water bodies and parallel to the skid trail, with butts toward the landing. Avoid felling trees into streams or lakes, and promptly remove any trees inadvertently felled into a water body. Retain an uncut or partially cut strip of timber along major waterways. Avoid logging adjacent to water bodies during periods when erosion and sedimentation are likely to occur.

Logging debris accumulating in streams or lakes must be removed promptly and deposited above the high water mark. Scatter logging residue on skid trails and exposed soil areas with soil erosion potential. Properly dispose of human-generated wastes and litter.

4. Reforestation

Minimize soil disturbance by mechanical preparation methods. Conduct prescribed burns under proper conditions, and avoid exposing mineral soils. Comply with applicable federal, state, and local regulations governing chemical storage, transportation, handling, and application. Select a planting procedure that is least disturbing to the soil, and avoid planting when the soil has a high moisture content.

5. Integrated Pest Management

Harvest mature, diseased, or infected trees or stands. Use silvicultural systems prescribed specifically to minimize pest population development. Manage for tree species that are adapted to the specific soil and site. Favor diversity, and avoid establishing host tree species in areas where they may be susceptible to a particular insect or disease. Use pesticides judiciously to control disease and insect populations.

State Contact:

Robert J. Mather
Dept. of Natural Resources
(608) 266-1727

WYOMING

Reference: Wyoming Department of Environmental Quality. 1992. *Wyoming Nonpoint Source Management Plan: Silviculture Best Management Practices - Final Draft*.

BEST MANAGEMENT PRACTICES

1. Planning
2. Harvesting and Revegetation
3. Roads
4. Chemicals
5. Fire Management

1. Planning

Evaluate proposed timber harvest units to estimate the response on the affected watersheds to determine whether the proposed units are suitable for harvesting. This involves field examination, evaluation of existing data, analysis of potential watershed response, and professional judgment. Where adverse water quality or soil productivity impacts may result, the harvest unit design should be modified, individual units deleted, and/or natural recovery rate accelerated by using watershed improvement measures. This practice cannot be implemented by a layperson; technical assistance must be provided by a professional forester with input from the associated disciplines.

Closely manage all silvicultural activities within riparian areas to minimize ground disturbance. Use field reconnaissance to determine the need for establishing a buffer zone, the subsequent width necessary to achieve management objectives, and any

restrictions on harvesting activities. When determining the proper width of a buffer zone, consider factors such as slope, stream classification, channel stability, resources dependent on these areas, and fisheries habitat condition. A table is provided in the manual with general buffer widths based on slope. Operations on slopes greater than 40 percent need to be given special technical consideration and should be coordinated with the appropriate technical agencies.

Whenever wetlands occur within the boundaries of a proposed silvicultural management operation, the Corps of Engineers (COE) must be contacted to determine whether the proposed activities are authorized by regulation, exempt from regulation, or require a permit.

Minimize erosion and sedimentation by designing skidding patterns to fit the topography and avoid on-site and downstream channel impacts, the concentration of runoff, and erosion in meadows and riparian areas. Fell trees toward a predetermined skid pattern to reduce impacts from the tractor. Protect sensitive areas by winching logs directly out of the areas with a cable operated outside the areas. On steep slopes and in riparian areas where tractors cannot operate, use suspended log-yarding systems to minimize soil disturbance and site impacts. These systems include high-lead, skyline, helicopter, and balloon yarders.

Develop an oil and hazardous substance spill contingency plan whenever an activity requires the aboveground storage of hazardous substances or petroleum products. Federal regulation requires a plan when more than 1,320 gallons of petroleum products are stored, and state regulation requires that spills in excess of 25 gallons of gasoline or 10 barrels of crude oil are reported to the Wyoming Department of Environmental

Quality (DEQ). The plan should contain a predetermined system of responses to be implemented in the event of a spill that considers the following factors: the specific substance spilled; the quantity; its toxicity; proximity of the spill to waters; and the hazard to life, property, and the environment. Store petroleum products and hazardous substances on level ground at least 150 feet from riparian areas and within a diked area that has sufficient capacity to contain the largest theoretical spill.

Properly plan, locate, and design sewage and wastewater disposal facilities whenever temporary camps are necessary for the conduction of a silvicultural operation. These facilities should not generate health or water pollution problems. Construction of permanent or temporary sanitary facilities requires a permit from the DEQ. Garbage and other solid wastes should be stored in animal-proof receptacles and disposed of at a properly designed, operated, and permitted landfill.

Development of water sources should be consistent with water quality protection and should aim toward the development of durable long-term sources rather than the construction of hasty, expedient developments. Do not reduce downstream flow so as to detrimentally affect aquatic resources, fish passage, sensitive species, or other uses, and remove temporary facilities prior to causing resource damage.

Time operation to not interfere with fish spawning and/or migration. Construct temporary cofferdams with materials that will not introduce sediment into the watercourse. Route overflow directly back into the watercourse. Contact the State Engineer before developing any water storage facility or diversion. Also, a section 404 permit may be required from the COE.

Soil and water resource monitoring and evaluation should be conducted to ensure

compliance with state water quality standards. A specific monitoring approach is not required, but the following factors should be considered when deciding on a monitoring regime: the size and type of operation, the amount of road building required, and the types of waterbodies at risk. A specific monitoring and evaluation plan should include:

- monitoring objectives;
- review of existing data and information;
- characteristics to be monitored;
- types, techniques, and frequency of monitoring;
- data analysis and evaluation;
- reporting; and
- cost.

When waterbody degradation or a water quality standard violation occurs, remedial action must be taken immediately. This may involve rescheduling, redesigning, mitigation for damage, or closing the operation.

2. Harvesting and Revegetation

Carefully manage equipment operations in wetlands, even if the area is in a dry state, to minimize erosion and water quality degradation. Tractor operations in these areas may be limited to specialized equipment and/or entering the area during favorable weather conditions.

Apply stream channel protection practices to provide unobstructed streamflow and fish passage, to maintain ambient stream temperatures, to minimize introduction of sediment and pollutants to watercourses, and to restore watercourses to natural courses after diversions. Avoid stream diversions unless performed under the recommendation and guidance of a professional hydrologist or engineer, and contact the State Engineer's office before constructing any diversion. Plan the location and method of stream crossings

prior to the commencement of the operation, and design harvest units to minimize construction along watercourses and riparian areas. Do not operate wheeled or tracked equipment in stream channels, except during stream crossing construction; when groundskidding, end-line logs out of streamside areas. Remove construction or logging debris that accidentally enters watercourses and place above the ordinary high water mark. Use water bars and other erosion control structures to minimize erosion and dissipate concentrated flows. At the close of operations, return the stream channel and banks to their original condition.

Locate and design landings to minimize erosion and water quality degradation. Do not locate landings in riparian or buffer areas. Landings should be located to minimize the required number of skid roads, to utilize existing terrain that does not exceed 10 percent slope, and where the minimum amount of excavation and sidecasting is needed. Where possible, locate landings near ridge points to facilitate skidding without crossing natural drainages or riparian areas. The landing size should not exceed that necessary for safe and efficient skidding. Shape landings to drain in a planned direction and to minimize erosion potential.

Provide erosion control measures on skid trails as harvesting operations proceed. These measures may include construction of cross ditches, backblading, slash placement, and grass seeding. Maintain all erosion control and stream crossing structures to ensure that they are functioning effectively.

Upon the completion of operations, landing areas should receive treatment to reduce surface compaction and enhance infiltration and revegetation. Treatment can include scarifying, smoothing and sloping construction of drainage ditches, diversion of runoff prior

to entering the landing, spreading of slash, mulching, and revegetation.

Other areas disturbed by harvesting operations (e.g., roads, skid trails, and firelines) may also require revegetation. Consult a professional forester, conservation district, or agricultural office for information on appropriate soil preparation, seed mixtures, application of mulch and fertilizer, and timing of revegetation efforts. If fertilizer is applied, protect surface water and ground water.

3. Roads

Time road construction activities to minimize erosion and avoid impacts to fish migration and spawning. Restrict operations during periods of excessive moisture.

Locate and design roads and trails to minimize impacts on soil and water resources and to ensure that they drain naturally by appropriate use of outsloping or insloping with cross drainage and grade changes. Whenever reliance on natural drainage is not sufficient, install relief culverts and roadside ditches. Use appropriate technical staff to evaluate the effects of transportation needs and operation and to recommend mitigating measures. Design roads to the minimum standards necessary to accommodate anticipated traffic volumes and to minimize erosion and disruption of water flow. Stream crossing structure design should involve a hydrologic analysis to determine runoff rates and volumes, flood conditions, velocities, scour, open channel shapes, approach topography, materials foundation conditions, and fish passage requirements.

Reduce chances for road-related mass failures, including landslides and embankment slumps. Provide subsurface drainage where it is necessary to avoid moisture saturation and subsequent slope failure. Horizontal drains,

drainage trenches, or drainage blankets may be used to lower subsurface water levels. Control the composition and characteristics of embankments in areas with high landslide potential. Do not incorporate slash or organic debris in embankments, and place embankment material by layer placement, controlled compaction, or controlled compaction using density-controlled strips.

Minimize sediment production and mass wasting during pioneer road construction. Confine pioneer roads to the corridor of the planned road. Prevent undercutting of the final cut slope, avoid deposition of materials outside designated roadway limits, and accommodate drainage with culverts or log crossings. Perform erosion control activity concurrent with construction.

Reduce sedimentation from unconsolidated excavated and sidecast material during road construction and maintenance. The area of exposed material can often be reduced by strict adherence to the lines, grades, and dimensions detailed in the road design. Prior to commencing construction activities, locate waste areas where excess material can be deposited and stabilized; do not locate such areas in stream channels, floodplains, wetlands, or riparian areas. On steep slopes, use end hauling and retaining structures as necessary. Supplement normal erosion control with special mitigation measures.

Minimize the number of stream crossings, and cross perpendicular to stream flow. Design and install structures to provide unobstructed stream flow and fish passage and to minimize damage to the watercourse. Minimize stream bank excavation. Temporary stream-crossing structures should be removed upon completion of operations.

When installation of permanent bridges or culverts is necessary, minimize sedimentation

and turbidity resulting from excavation. All construction should be performed during periods of low flow and should not interfere with fish spawning or migration. Divert stream flow around the construction site. The State Engineer must be notified of all stream diversions, and a COE permit may be required. Minimize operation of mechanical equipment in live streams. Do not deposit material in watercourses, and do not stockpile material on floodplains. If the groundwater contribution is significant during excavation in or near the stream course, use cofferdams, caissons, cribs, or sheet piling; otherwise, pump water away from the excavated area. Do not discharge pumped water directly to the watercourse, but to a settling basin.

Implement erosion control practices during and after road construction and prior to seasonal precipitation and runoff. Erosion control is extremely important on projects that incomplete at the end of the normal operating seasons. Revegetate exposed soils in conjunction with mulching and fertilization. Implement measures that physically protect the soil surface from detachment or modify the topography to minimize erosion. These measures can include treating the roadway and ditches with chemical additives; using mulches, riprap, or erosion mats; terracing on cuts, fills, and ditches; and installing water bars on temporary roads. Waste oil is not appropriate as a surface treatment for forest roads. Use slash filter windrows, catch basins, anchored straw bales, or other water-spreading devices to inhibit downslope movement of sediment. Reduce soil disturbance in or near streams by dewatering culvert installations and immediately installing culverts during road pioneering. Do not use temporary pipes unless sedimentation can be controlled during installation, use, and removal. Properly design and construct road drainage systems and drainage control structures. Control the flow of surface and

subsurface water by insloping, outsloping, and/or installing ditches, cross drains, underdrains, trenches, water-spreading devices, energy dissipators, and other similar structures.

Minimize sediment production from borrow pits, gravel sources, and quarries. Provide temporary erosion control during excavation and permanent erosion control and rehabilitation after excavation is complete. Borrow pits and gravel sources located in floodplains require special attention and planning. Excavation should be limited to above the normal high water mark. Contact the DEQ before beginning operations.

Close or obliterate temporary roads. Remove temporary culverts and bridges, and restore the natural drainage configuration. Reshape and stabilize side slopes. Effectively drain and block the road, and revegetate.

4. Chemicals

Handle, transport, and apply pesticides in accordance with the product label to reduce or eliminate possible adverse effects on water quality. Retain a buffer area of at least 150 feet along surface waters during application of pesticides. Do not aerially apply chemicals if there are label restrictions prohibiting aerial application. Develop a spill contingency plan. Maintain records documenting the type and mixture of chemical applied, area of application, amount, rate, method and time of application, and name of the person performing the application. Pesticide applications should be monitored and evaluated to provide feedback on the placement, accuracy, application amount, and any water contamination that might occur. Monitoring and evaluation methods include spray cards, dye tracing, and direct measurement of pesticides in or near water. Type of pesticide, equipment, application difficulty, public

concern, beneficial uses, monitoring difficulty, availability of competent laboratory analysis, and applicable federal, state, and local laws and regulations are factors considered when determining the monitoring and evaluation needs.

Clean and dispose of pesticide containers and equipment in accordance with federal, state and local laws, regulations, and directives. Rinse containers three times, and apply the rinse water to the project area. Maintain records documenting container disposal.

Handle and apply fertilizers to reduce or eliminate possible adverse effects on water quality. Perform a soil test to confirm the need for fertilization. Retain a buffer area between the surface waters and the fertilized area. The width of this buffer area is determined by slope, vegetation, and soil conditions. Maintain records documenting the type of fertilizer applied, area of application, amount applied, and method and time of application.

5. Fire Management

Protect soil and water from the effects of prescribed burning. Avoid intense fires that may promote water repellency, nutrient leaching, and erosion. Construct water bars in firelines. Remove all debris added to stream channels as a result of the burn. Retain or plan for sufficient ground cover to prevent erosion of the burned sites.

Stabilize all areas that have had their erosion potential significantly increased or their drainage patterns altered by fire suppression-related activities. Install water bars and other drainage diversions in fire roads, firelines, and other cleared areas. Spread slash or mulch to protect exposed soil, and revegetate. Remove debris from stream channels deposited by

suppression activities. Repair damaged road drainage facilities.

Apply emergency rehabilitation treatments to areas where wildfire burn is expected to degrade water quality. These treatments can include revegetating, fertilizing, fencing to protect new vegetation, clearing debris from watercourses, and constructing channel-stabilization structures and debris-retention structures.

State Contact:

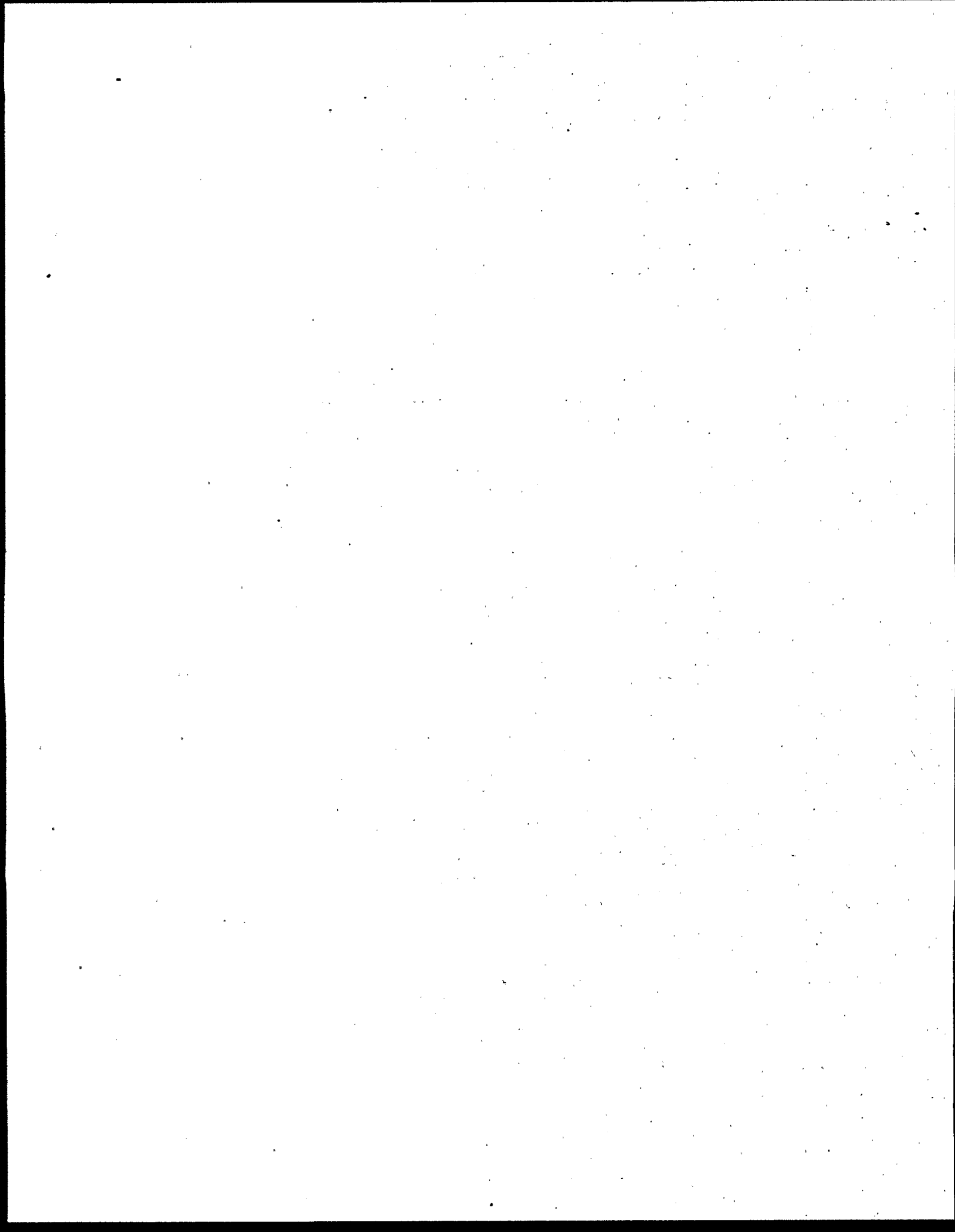
Herbert Cottrell
State Forest Division
(307) 777-7586
FAX: 637-8726

Other Available State Information

Brochures *Clean Water Ways* is an NPS newsletter; *Wyoming Hydrogram* is a newsletter published by Wyoming's Water Resources Center

APPENDIX A

OVERVIEW MATRICES OF STATE BEST MANAGEMENT PRACTICES



Tables

Number		Page
A-1	Overview of Revegetation Practices	A-1
A-2	Overview of Road Surface Drainage	A-4
A-3	Overview of Skid Trail Practices	A-8
A-4	Overview of Stream Crossing Practices	A-11
A-5	Overview of Streamside Protection Practices	A-15

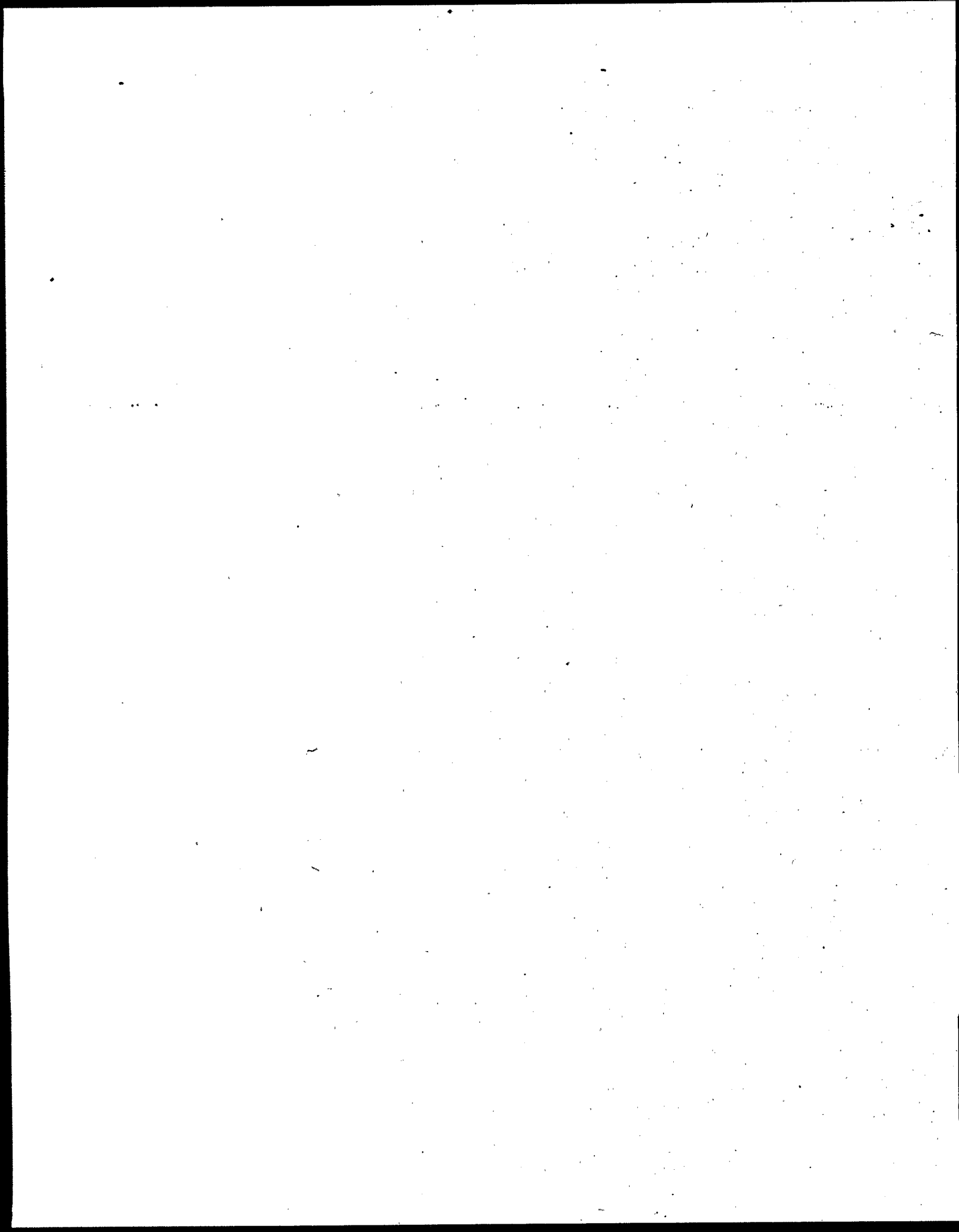


Table A-1. Overview of Revegetation Practices

STATE	SEED MIXTURES	MULCH	FERTILIZER/LIME	TIMING/SEEDBED PREPARATION
Alabama	Obtain from local offices of SCS or Cooperative Extension	Recommended; apply immediately after seeding	Soil test recommended; incorporate into soil	Shape and smooth surface; rip or disk heavily compacted areas
Alaska	None			
Arkansas	Seeding recommended on bare soils, but no specifications provided			
California	Stabilization required, but no specifications provided			
Connecticut	Types and rates; multiple species recommended	Scattered hay, wood chips, saw dust	Ground limestone: 100 lbs/1000 sq. ft. for acidic soils	"Rough-up" heavily compacted or rutted sites
Delaware	Types, rates, dates; based on surface and weather conditions	Apply immediately after seeding on erodible soils or during adverse conditions; hay/straw: 1-1.5 tons/acre wood fiber mulch: 1500 lbs/acre;	Soil test recommended; rates determined by soil type/acidity; 1.5 tons lime and 600 lbs of 10-10-10 per acre	As season permits; shape surface; rip compacted soils
Florida	Types, rates; based on soil quality and region		Base on soil or foliar analysis; apply in early spring	
Georgia	Types, rates; based on region and seeding dates	Hay: 5000 lbs/acre; Small grain straw: 4000 lbs/acre	800-1000 lbs/acre of 6-12-12; no BMPs	
Idaho	Stabilization required, but no specifications provided; specifications provided for buffer widths during fertilizer applications			
Illinois			BMPs provided	
Indiana	Tall fescue: 20 lbs/acre; Annual rye: 5 lbs/acre	Hay: 5 to 6 straws deep	10-10-10 at 100 lbs/acre	Spring till 5/15; 8/15 to 9/30
Kentucky	Types, rates, dates; based on soil/surface quality and intent (wildlife usage)	Various types; rates and application remarks provided	Incorporate to a depth of 4"-6"; 70-80 lbs N; 120 lbs P ₂ O ₅ ; 120 lbs K ₂ O	Grade area; scarify surface
Louisiana	None			
Maine	Obtain from local offices of SCS or Cooperative Extension; consider wildlife habitat enhancement; 20 lbs/acre creeping red fescue	Hay, cereal straw, bark, native vegetation; maybe slash; apply hay at 60 bales/acre	400 lbs/acre of 5-10-10 or 5-10-5	Immediately following construction; grade and scarify surface
Maryland	Types, rates, dates; based on region and site conditions	Apply immediately after seeding on erodible soils or during adverse conditions; hay/straw: 1-1.5 tons/acre; wood fiber mulch: 1500 lbs/acre	Soil test recommended; rates determined by soil type/acidity; 1.5 tons lime and 600 lbs of 10-10-10 per acre	Within 7 days on slopes > 30%, otherwise end of harvesting; shape and rip surface

Table A-1. Continued

STATE	SEED MIXTURES	MULCH	FERTILIZER/ LIME	TIMING/SEEDBED PREPARATION
Massachusetts	Types, rates, soil pH range	Hay: 60 bales/acre	2 tons/acre of lime; 400 lbs/acre of 5-10-10 or 5-10-5	4/15 to 6/15; 8/1 to 9/15
Michigan	Stabilization suggested, but no specifications provided			
Minnesota	Obtain from local offices of SWCD, USFS, DNR, county extension	Yes		As soon as practical after construction
Mississippi	Types, rates, dates, remarks for both temporary and permanent vegetation; based on soil and site conditions; SCS guidelines provided	Apply immediately after seeding on erodible soils or during adverse conditions; SCS guidelines provided	2 tons/acre of lime; 400 lbs/acre of 10-10-10	Smooth and shape surface
Missouri	Rates, dates	Light mulch on droughty soils		
Montana	Revegetation recommended, but no specifications provided			
Nevada	Revegetation recommended, but no specifications provided			
New Hampshire	Types, rates for both temporary and permanent vegetation; based on area, drainage, soil pH, shade	Critical areas and droughty soils; hay or straw: 90 lbs/1000 sq. ft.	Determine by soil test; lime to pH 6.0; 2 tons/acre limestone (high Mg); 500 lbs/acre 10-10-10	Grade and scarify surface (at least 3" deep)
New Jersey	None			
New Mexico	Rates provided for various application methods; based on region	Hay, straw, wood chips		June or early July
New York				
North Carolina	Discusses various seeding methods; provides information on seed mixtures, rates, dates, fertilizer, mulch, and maintenance for the major physiographic regions and soil/site conditions; discusses mulching materials and chemical stabilizers			
Ohio	Mixture type based on type of disturbance; 50 lbs/acre	Straw preferred; provides rate, use and anchoring guides	20 lbs/acre of 14-14-14; 400 lbs/acre of pelletized lime	
Oklahoma	Types, rates, dates; various application methods discussed	Hay: 2.5 tons/acre	52-52-52 lbs/acre	Loosen soil
Oregon	None			
Pennsylvania	Types, rates; wildlife usage included	2.5-3.0 tons/acre of straw or hay	Soil test recommended; 4 tons/acre of lime; 100-200-200/acre	Scarify
Rhode Island	General purpose mix and rate	Hay: 500 lbs/acre	1 ton/acre of limestone; 500 lbs/acre of 10-10-10	
South Carolina	None			

Table A-1. Continued

STATE	SEED MIXTURES	MULCH	FERTILIZER/LIME	TIMING/SEEDBED PREPARATION
Tennessee	Types, rates, dates, remarks for temporary and permanent vegetation	70 lbs/1000 sq. ft. of clean straw or unmolded hay	Soil test recommended; 2-3 tons/acre of lime 300 lbs/acre of 15-15-15 for temporary veg and 1000 lbs/acre of 6-12-12 for permanent veg	8/15 to 10/15 or 2/15 to 4/15; shape and smooth area; scarify surface
Texas	Revegetation suggested for slopes greater than 5%, but no specifications provided			
Vermont	Type, rate, dates	Hay: 60 bales/acre	2 tons/acre of lime; 240 lbs/acre of 10-10-10	During seasons/weather favorable for germination
Virginia	Types, rates, dates, remarks; based on physiographic regions; critical area planting included	Apply immediately after seeding on erodible soils or during adverse conditions; hay/straw: 1-1.5 tons/acre; wood fiber mulch: 1500 lbs/acre	Rates determined by soil type/acidity; 1.5 tons lime and 600 lbs of 10-10-10 per acre	As season permits; shape and rip surface
Washington	BMPS provided			
West Virginia	Revegetation suggested, but no specifications provided			
Wisconsin	Revegetation encouraged, but no specifications provided			
Wyoming	Vegetative stabilization recommended, but no specifications provided; BMPs for fertilizers provided			

Table A-2. Overview of Road Surface Drainage

STATE	DRAINAGE STRUCTURES	SURFACE DESIGN/CONSTRUCTION	OTHER
Alabama	Wing ditches, Coweeta dip, broad-base dip; recommended spacing distances are provided	Crown, out-slope, in-slope	Direct discharge from drainage structures onto undisturbed forest floor or energy dissipators
Alaska	Cross drains, ditches, relief culverts, water bars, diversion ditches; recommended spacing distances are provided	Protect roadbed from rutting, ground disturbance, or thermal erosion	Direct discharge from drainage structures onto vegetated areas and away from unstable soils
Arkansas	Diversion and wing ditches, cross drains, culverts	Crown, out-slope	Adequately size culverts to accommodate anticipated water flow; do not direct discharge from drainage structures onto erodible material
California	Drainage structures of sufficient size, number, and location to minimize erosion; specifications for water break spacing, installation and maintenance are provided	When in-sloping, provide adequate cross-drainage	Do not direct discharge from drainage structures onto erodible material unless energy dissipators are used
Connecticut	Diversion dips, broad-based dips, water bars, ditch-relief culverts (pipe and open-top culverts); spacing distances are recommended	Out-slope or in-slope to $\frac{1}{4}$ to $\frac{3}{4}$ inch; crown roads to twice the pitch of in-sloped or out-sloped roads	Protect discharge area with stone, grass sod, logs, tree tops, or natural litter
Delaware	Turnouts, broad-based dips, rolling dips, pipe and open-top culverts, water bars; specifications for drainage structure spacing and installation are provided	Out-slope road where gradient and soil type permit; in-slope roads on grades of 15 percent or greater or on slippery soils; use cross drainage on in-sloped or crowned roads	Direct discharge from drainage structures onto undisturbed areas; apply 2 to 3 inches gravel on steep grades
Florida	Culverts, cross ditches, turnouts, broad-based dips, water bars; specifications for drainage structure spacing are provided and are based on site sensitivity classification		Direct discharge from drainage structures onto vegetated areas of adequate size to assimilate sediment loads
Georgia	Turnouts, broad-based dips; specifications for drainage structure spacing and installation are provided	Avoid in-sloping roads	Avoid use of soft roads during wet conditions
Idaho	Relief culverts, roadside ditches, dips, water bars	Out-sloping, in-sloping with cross drainage, grade changes	
Illinois	Drainage ditches		Disperse road drainage onto stable forested areas and not directly into streams
Indiana	Drainage dips, water breaks; recommended spacing distances are provided		Do not operate equipment when rutting in excess of 8 inches is occurring
Kentucky	Culverts, drainage dips, water bars; recommended spacing distances are provided	Out-slope entire width of road to a slope of $\frac{1}{4}$ inch per foot or in-slope and install additional drainage structures	Minimize road use during wet weather unless surface materials permit all-weather use

Table A-2. Continued

STATE	DRAINAGE STRUCTURES	SURFACE DESIGN/CONSTRUCTION	OTHER
Louisiana	Ditches, culverts, cross drains, water bars	Crown, out-slope	Restrict traffic during periods of excessive ground moisture
Maine	Broad-based drainage dips, skid humps, water bars, cross drainage culverts; recommended spacing distances are provided	Crown roads where possible	Direct discharge from drainage dips into an undisturbed vegetated area
Maryland	Turnouts, broad-based dips, rolling dips, culverts; recommended spacing distances are provided	Out-slope road where gradient and soil type permit; use cross drainage on in-sloped or crowned roads	Direct discharge from drainage structures onto undisturbed forest floor or install energy dissipators
Massachusetts	Broad-based dips, water bars, open-top and pipe culverts; Specifications for design and spacing are provided	Crown road surfaces	Direct discharge from drainage structures into filter strips or hay bale impoundments; gravel or mulch access roads to minimize transport of sediment to public highways
Michigan	Broad-based dips, water bars, cross-drainage culverts; recommended spacing distances are provided	Out-slope road where gradient permits; in-slope roads on grades of 15 percent or greater or on slippery soils	Install energy dissipators at cross-drainage culvert outlets
Minnesota	Dips, water bars, open-top culverts, cross drainage; recommended spacing distances are provided	Surface road grades with significant erosion potential; shape in-slopes and backslopes to be 1½:1 or flatter	Direct discharge from drainage structures into filter strips or vegetative draws, not open waters
Mississippi	Broad-based dips, water bars, culverts; specifications for design and spacing are provided	Out-slope the entire width of the road	Install erosion protection measures at pipe outfalls
Missouri	Broad-based dips, turnouts, culverts, water bars; specifications for design and spacing are provided	Gravel surface where necessary to prevent erosion	
Montana	Cross-drains, culverts, water bars, dips; figures are provided for drainage techniques	Out-slope or crown roads; inslope roads with ditches and cross-drains	Direct discharge from drainage structures into SMZs, filtration fields, or other sediment settling structures; do not discharge onto erodible soils
Nevada	Water breaks, culverts, dips, cross-ditches, turnouts; specifications for design and spacing are provided	Out-sloping	
New Hampshire	Broad-based dips, water bars, reverse grades, cross-drainage culverts, open-top culverts; specifications for design and spacing are provided	Out-slope road in solid (rock) areas or where discharge will be onto undisturbed forest floor; in-slope roads on wet or erodible soils; crown roads on steep side hills; surface road (with gravel or crushed rock) if needed to prevent rutting or erosion	Dissipate discharge from drainage structures with stone, grass sod, litter cover, slash, or logs; restrict traffic during saturated soil conditions
New Jersey	Drainage structures		Discharge runoff away from streams

Table A-2. Continued

STATE	DRAINAGE STRUCTURES	SURFACE DESIGN/CONSTRUCTION	OTHER
New Mexico	Grade dips, cross-drains, water bars, open-top culverts; specifications for design and spacing are provided	Crown roads located on ridge tops and fairly level land; on moderate slopes, out-slope roads to $\frac{1}{4}$ - $\frac{1}{2}$ inch/foot width; in-slope roads on steep slopes or unstable soils and install cross drains	Dissipate discharge from drainage structures with rocks, slash, vegetation, or other energy absorbing material
New York	Drainage structures		Discharge runoff away from streams
North Carolina	Turnouts, broad-based dips, rolling dips, pipe culverts, water bars; specifications for design and spacing are provided	Where conditions allow, out-slope the entire road width; on steep slopes, use crushed stone on road surface	Install an energy absorber at drainage structure outlets to minimize erosion
Ohio	Turnouts, broad-based dips, rolling dips, pipe culverts, open-top culverts; specifications for design and spacing are provided		
Oklahoma	Ditches, culverts, cross drains, drainage dips, water bars; specifications for design and spacing are provided	Crown, out-slope	Do not direct discharge from drainage structures onto erodible material unless energy dissipators are used
Oregon	Dips, water bars, cross drains, culverts	Out-sloping and grade changes	
Pennsylvania	Culverts, broad-based dips, water bars; specifications for design and spacing are provided	In-slope or out-slope road to divert water	Install an energy absorber at drainage structure outlets to minimize erosion
Rhode Island	Culverts, broad-based dips; recommended spacing distances are provided		During wet weather, avoid using roads
South Carolina		Maintain road surfaces by grading and out-sloping	Provide adequate cross drainage and divert water into areas with good ground cover
Tennessee	Broad-based dips, culverts, turnouts, water bars; specifications for design and spacing are provided	Crown roads located on flat land; out-slope roads on moderate slopes; in-slope roads on steep, sharp turns and slippery soils	Direct discharge from drainage structures onto heavy litter, grass sod, rock, or other energy absorbing materials
Texas	Broad-based dips, rolling dips, water bars, pipe and open-top culverts, turnouts; specifications for design and spacing are provided	Out-slope road where gradient and soil type permit; in-slope roads on steep, sharp turns and slippery soils; use cross drainage on in-sloped or crowned roads	Install an energy absorber at drainage structure outlets to minimize erosion
Vermont	Broad-based dips, pipe and pole culverts, ditches, water bars, turnups; specifications for design and spacing are provided		Design ditches to discharge onto undisturbed, vegetated land
Virginia	Broad-based dips, rolling dips, pipe and open-top culverts, water bars, turnouts; specifications for design and spacing are provided	Out-slope road where gradient and soil type permit; in-slope roads on steep, sharp turns and slippery soils; use cross drainage on in-sloped or crowned roads	Install an energy absorber at drainage structure outlet to minimize erosion

Table A-2. Continued

STATE	DRAINAGE STRUCTURES	SURFACE DESIGN/CONSTRUCTION	OTHER
Washington	Dips, diversion ditches, culverts, cross drains, waterbars; specifications for design and spacing are required	Out-slope road	Do not direct discharge from drainage structures onto erodible material unless energy dissipators are used
West Virginia	Broad-based dips, culverts, ditches, water bars, specifications for design and spacing are provided	Out-slope entire road width to $\frac{1}{4}$ inch where possible, otherwise in-slope and install cross drainage	Direct discharge from drainage structures onto vegetated areas and/or install energy dissipators
Wisconsin			Provide road surface drainage
Wyoming	Water bars, ditches, cross drains	In-sloping, out-sloping	Treating with chemical additives to minimize soil detachment

Table A-3. Overview of Skid Trail Practices

STATE	LAYOUT	DRAINAGE STRUCTURES	REVEGETATION	OTHER
Alabama	Skid uphill to landing	Water bars; no specifications provided	Success equals 75% cover; recommendations for seed, mulch, and fertilizer provided	
Alaska	Avoid steep slopes	Water bars; no specifications provided		Minimize trail widths
Arkansas	Utilize topography	Water bars; no specifications provided	Seed - no specifications provided	Do not use stream channels as trails
California	No trails: on slopes >65%; on slopes >50% that lead to (without flattening) Class I or II watercourses; or in areas with average slopes >50% and high erosion hazard rating	Water breaks; specifications provided for spacing and installation		
Connecticut	Skid uphill away from streams	Pole culverts, broad-based dips, water bars; specifications provided	Seed steep sections; use seed mixtures from several species and mulch; recommended seed mixtures provided	
Delaware	Locate landings first; no grades > 15%; skid uphill; use zig-zag patterns	Culverts, water bars; specifications provided	Permanent vegetative cover; specifications provided	Do not skid through perennial or intermittent stream channels
Florida	Skid uphill; concentrate trails on organic soils and disperse trails on mineral soils	Water bars		
Georgia	Alternate skidding between several trails rather than one primary trail	Temporary culverts	Seeding specifications provided	
Idaho	Uphill yarding	Water bars, cross drains		Minimize number and width of trails
Illinois	Avoid high-hazard areas; use low grades			Minimize number and width of trails
Indiana				Keep natural drains open
Kentucky	Locate landings first; use low grades; use zig-zag patterns	Water diversions, cross drains, waterbars	Specifications provided for revegetation	
Louisiana	Skid away from perennial and intermittent streams; avoid steep slopes			Do not use streambeds as trails; minimize number of trails on steep slopes
Maine	Avoid steep grades	Water bars, water turnouts; specifications provided	Recommended on steep sections; some specifications provided	Keep skidding distances < 1/2 mile

Table A-3. Continued

STATE	LAYOUT	DRAINAGE STRUCTURES	REVEGETATION	OTHER
Maryland	Locate landings first; use low grades; use zig-zag patterns	Water bars	On trails >5% slope; specifications provided	Skid outside SMZs
Massachusetts	Use low grades	Water bars	Yes; specifications provided	
Michigan	Use low grades; use zig-zag patterns; use several trails, not 1 primary trail		Yes	Skid outside buffer strip
Minnesota	Minimize long, straight trails	Water bars, dips	Yes; specifications provided	Avoid filter strips
Mississippi	Locate landings first; use low grades	Water turnouts, water bars, cross drains	Seed slopes >15%; specifications provided	
Missouri				
Montana	Designate prior to operations; locate to avoid concentrating runoff	Water bars	Yes	
Nevada		Water breaks		Do not skid in streams
New Hampshire	Skid uphill to landings		Yes; specifications provided	Avoid filter strips; do not skid in streams
New Jersey				Minimize number of trails; do not skid in streams or on banks
New Mexico	Plan prior to logging	Water bars	Yes; specifications provided	Avoid streams
New York				Minimize number of trails; do not skid in streams or on banks
North Carolina	Concentrate skidding to a few primary trails; use zig-zag pattern; skid uphill	Water bars	Yes; specifications provided	Skid outside SMZs; do not skid in streams
Ohio	Use grades <20%	Water bars		Do not skid through streams
Oklahoma	Skid upslope on the contour	Water bars	Yes; specifications provided	Skid outside SMZs
Oregon				
Pennsylvania	Locate landings first; do not skid straight up the slope	Water bars	Yes; specifications provided	Do not skid in streams or spring seeps
Rhode Island	Locate landings first; skid downslope	Dips	Yes; specifications provided	Avoid streams
South Carolina	Use low grades			Limit trail number and size

Table A-3. Continued

STATE	LAYOUT	DRAINAGE STRUCTURES	REVEGETATION	OTHER
Tennessee	Use grades <10%; use zig-zag patterns; skid uphill	Water bars, dips	Yes; specifications provided	Avoid streams and SMZs
Texas	Locate landings first; use grades <15%	Water bars	On slopes >5%	Avoid streams and SMZs; ruts should not exceed 6" deep
Vermont	Use low grades with gradual angle; build from top down	Dips, pole culverts, water bars; specifications provided	Yes; specifications provided	
Virginia	Locate landings first; use grades <15%; use zig-zag patterns	Water bars	On slopes >5%	Skid outside SMZs; ruts should not exceed 6" deep
Washington	Skid above 50-yr flood level	Water bars		Minimize trail width
West Virginia	Use low grades			
Wisconsin	Use low grades	Water bars	Encouraged	Minimize trail width; avoid streams and SMZs
Wyoming	Fit topography	Water bars	As necessary	Minimize trail width; avoid streams

Table A-4. Overview of Stream Crossing Practices

STATE	CULVERT/BRIDGE SIZING	ALIGN- MENT	INLET/OUTLET CONTROLS	FISH PASSAGE	TEMPORARY CROSSINGS	FORDS
Alabama	Recommended diameters	YES	Rock	Provide for normal passage of aquatic animals	Log crossings; must be removed	Firm streambed; banks low; stream shallow; stabilize approaches
Alaska	12" diameter min; permanent structures for 50- yr flood		Culverts not perched at inlet/outlet; bulkheads; retaining walls; riprap; rock spillways; splash plates	Must provide for	Must pass 25-yr flood	At low flow
Arkansas	Pass normal flood levels; not constrict flow	YES			Remove after use	Yes - no specifications
California			Stabilize approaches	Unrestricted passage		
Connecticut	12" diameter min; based on soil type and drainage area	YES	Construct settling basin at inlet if culvert lower than streambed; headwall; large stone			Can use on skid trails if beds and approaches are stable
Delaware	15" diameter min; based on soil type and drainage area; do not impede flow	YES	Protect culvert outlet with riprap, stone, etc.	Do not impede		Stable banks and hard bottoms
Florida	Size to maintain streamflow	YES			Recommended	Should not impede flow
Georgia	12" diameter min; based on drainage area and geographic region; do not impede flow	YES				Banks and bottoms hard and level; temporary
Idaho	18" diameter min; based on region and watershed drainage area; 50-yr peak flow			Must provide for fish passage		
Illinois	Should not constrict flow	YES	Riprap; rock spillways; splash plates; aprons; energy dissipators		Should not constrict flow	Use on skid trails during periods of low flow; low stable banks and firm bottoms

Table A-4. Continued

STATE	CULVERT/BRIDGE SIZING	ALIGN- MENT	INLET/OUTLET CONTROLS	FISH PASSAGE	TEMPORARY CROSSINGS	FORDS
Indiana		YES			Remove	Use on small streams; riprap approaches
Kentucky	12" diameter min; chart for sizing based on drainage area and elevation	YES	Headwall; riprap; cement mixed w/ sand		Preferable	Gravel approaches
Louisiana	Should not constrict channel	YES			Remove	Firm bottoms, stable banks, gentle approaches
Maine	Do not impede flow; structure cross sectional area must be 2½ that of the stream's	YES		Do not impede	For small streams	Permitted in some instances
Maryland	15" diameter min; 18" dia preferred; sizing chart based on acres drained, slope and soil type	YES		Do not impede		Use when no practical alternative exists; stable banks; hard bottoms; stabilize approaches
Massachusetts		YES			For small streams; remove	
Michigan	Do not impede flow; determined by table based on watershed drainage	YES				
Minnesota	Must pass 25-50 year flood frequency	YES		Do not impede		Only where subgrade contains a lot of rock
Mississippi	Permanent structures must pass 5-yr/24-hr storm; table provided	YES	Headwall; riprap;	Must allow for passage	Must pass 2-yr/24-hr storm; table provided	Do not use in critical water areas; solid streambed; gravel approaches
Missouri		YES			Do not top with soil	Hard and level bottoms; protect with coarse rock
Montana	15" diameter min; handle peak flows	YES	Armored with rock	Must allow for passage		At stable, rocky places
Nevada	Do not constrict flow		Energy dissipators	Must allow for passage	Remove	

Table A-4. Continued

STATE	CULVERT/BRIDGE SIZING	ALIGN- MENT*	INLET/OUTLET CONTROLS	FISH PASSAGE	TEMPORARY CROSSINGS	FORDS
New Hampshire	12" diameter min; sizing chart based on drainage area and soil type	YES	Rock headwall; energy dissipators		Specifications provided for temporary bridges	Specifications provided for stone fords and poled fords
New Jersey					Use where bottoms or banks would otherwise be damaged; remove	
New Mexico	25-yr design storm; culvert area equation and table provided	YES	Riprap; construct wingwall on large streams		Specifications provided for log bridges	On stable, rocky portion of streams; properly stabilize
New York						
North Carolina	15" diameter min; charts provided based on Talbot's Formula; use bridges or multiple culverts if diameter > 48" required	YES			Specifications provided for log bridges	Minimize use; firm base; stabilize approaches
Ohio		YES			Do not put soil on top of logs placed in stream; remove	Where stream bed and banks are rock; stabilize approaches
Oklahoma	18" diameter min; use Hasty Method to determine size; do not constrict flow	YES	Retaining walls; bulkheads; riprap; energy dissipators; specifications provided		Use on skid trails	Yes
Oregon	25-yr storm	YES		Provide for passage		
Pennsylvania	12" diameter min; chart provided based on acres drained	YES				Only on haul roads, not skid trails; low banks; solid streambeds
Rhode Island		YES				
South Carolina	Must accommodate increases in stream flow	YES				

Table A-4. Continued

STATE	CULVERT/BRIDGE SIZING	ALIGN- MENT*	INLET/OUTLET CONTROLS	FISH PASSAGE	TEMPORARY CROSSINGS	FORDS
Tennessee	15" diameter min; chart based on drainage area and soil type	YES				Avoid where possible; solid bottoms
Texas	15" diameter min; chart based on acres; pass normal flood level; do not constrict channel	YES	Riprap, large stone		Remove promptly	Only if no practical alternative exists
Vermont	Based on drainage area; handle largest potential flow					Stable beds and approaches; figure of poled fords
Virginia	15" diameter min; chart based on acres drained, slope, and soil type; do not constrict channel	YES		Do not impede		If no practical alternative exists; hard bottoms and approaches
Washington	Chart for determining permanent culvert sizes; bridges must pass 50-yr flood level; do not constrict channel	YES		Do not impede	Remove promptly	
West Virginia	Size to handle large flows	YES	Apron of rock or other material		Log crossings on small streams; remove promptly	
Wisconsin	Adequately size				Remove promptly	Avoid unless streambed and banks are stable
Wyoming	Structure design should involve hydrologic analysis; do not obstruct flow	YES		Allow for fish passage	Remove	

* Alignment refers to installing crossing perpendicular to streamflow.

Table A-5. Overview of Streamside Protection Practices

STATE	NAME ^a	WIDTH ^a	SHADING/STREAM-TEMPERATURE ^b	LOGGING REQUIREMENTS ^b	APPLICABILITY ^b
Alabama	SMZ	35' minimum	50% crown cover for P streams; vegetative cover for I streams	Partial cut within 35' minimum	P/I
Alaska	RA	Varies by landowner type and water body classification		No timber harvesting within 66' to 100' of water body (depends on land type and water body classification)	
Arkansas	SMZ	Site specific; no minimum	Leave enough trees, but no specific requirements	Selective logging	
California	WLPZ	Varies by slope and Water Class; 50' min for Class I & II	Varies by Water Class; 50% canopy retention maximum	Varies by Water Class; 50% understory retention maximum	All watercourses and lakes
Connecticut	FS	25' min; varies by slope			
Delaware	SMZ	50' min; 100' min on heavily erodible slopes	60% crown cover or 60 sq ft of basal area/acre	Partial cut	P; bodies of open water
Florida	SMZ	35' min (primary zone); varies by site sensitivity classification (secondary zone); 300' max (discretionary zone)		Primary SMZ - selective cut leaving a volume \geq 1/2 original; secondary SMZ - clearcut	P/I; lakes \geq 10 acres
Georgia	SMZ	Primary zone (20'-80'); secondary zone (0'-80') varies by region		Do not use wheeled or tracked vehicles in primary zone	P/I; lakes; ponds
Idaho	SPZ	75' min on Class I stream; 5' min on Class II stream	Retain 75% current shade; standing tree requirements within 50' on Class I streams varies by stream width and DBH	No tracked or wheeled skidding on slopes > 45% adjacent to Class I or II stream	P/I
Illinois	SMZ	No width specified	Provide shading; no specifications provided	Selective harvesting; minimize ground disturbance	P
Indiana	BS				
Kentucky	SMZ	30' min; 50' min on steep slopes; varies by slope	Retain 50% canopy	CAH ^c - 60' strip; leave understory undisturbed; remove only commercially high-value trees	P; lakes; ponds
Louisiana	SMZ	Larger the stream, wider the SMZ; site specific determination based on soil type, slope, vegetative cover, stream characteristics, and worst case storm flows			P/I; lakes

Table A-5. Continued

STATE	NAME ^a	WIDTH ^a	SHADING/STREAM TEMPERATURE ^a	LOGGING REQUIREMENTS ^a	APPLICABILITY ^b
Maine	FS	25' min; varies by slope	Provide for undisturbed area; width determined on-site	On P streams, partial cut $\leq 40\%$ of total timber volume $\geq 6"$ DBH over a 10 year period	P/I
Maryland	SMZ (BZ)	50' min on P streams; varies by slope - equation provided	On P streams, retain 60% crown cover or 60 sq ft of basal area/acre	Partial cut	P/I; surface waters
Massachusetts	FS	50' min; varies by slope and increases in critical areas	50% maximum basal area removed	Partial cut; 3 year intervals; winch	All surface waters
Michigan	BS	50' min; varies by slope		Retain 30 sq ft of basal area	P/I; lakes; ponds
Minnesota	FS	25' min; varies by slope	Along trout streams		P/I; lakes; ponds
Mississippi	FS	Varies according to slope and erosion hazard		Do not remove $> 50\%$ overstory when understory is absent	
Missouri	SMZ	Primary is 25'; secondary is variable		In primary zone, cut only $\frac{1}{4}$ of zone and cable timber; in secondary, $\frac{1}{4}$ cut but careful groundskidding allowed	P/I; springs; lakes
Montana	SMZ	50' min		Partial cut (no clearcuts)	Surface waters
Nevada	SMZ	Determined by on-site investigation	Retain $\geq 50\%$ original canopy		P; I that support fish; lakes
New Hampshire	FS	50' min; varies by slope		Do not expose mineral soil	Surface waters
New Jersey	BS	100' min on slopes $< 30\%$; 150' min on slopes $> 30\%$		Selective	Water bodies
New Mexico	BS	50' min; varies by slope		Do not disturb soil and vegetation	P/I
New York	BS	50' next to clearcuts; 100' min on slopes $< 30\%$; 150' min on slopes $> 30\%$		Do not cut	P; ponds; marshes
North Carolina	SMZ	50' min; varies by slope and type of water body	Retain sufficient shade on P streams to prevent temp fluctuations	Limited cutting	P/I; beneficial water bodies
Ohio	FS, SS	FS variable by slope and region (25'-450'); SS is 25'	No cut or light cut in SS	Selective harvesting along P streams	Watercourses
Oklahoma	SMZ				Watercourses

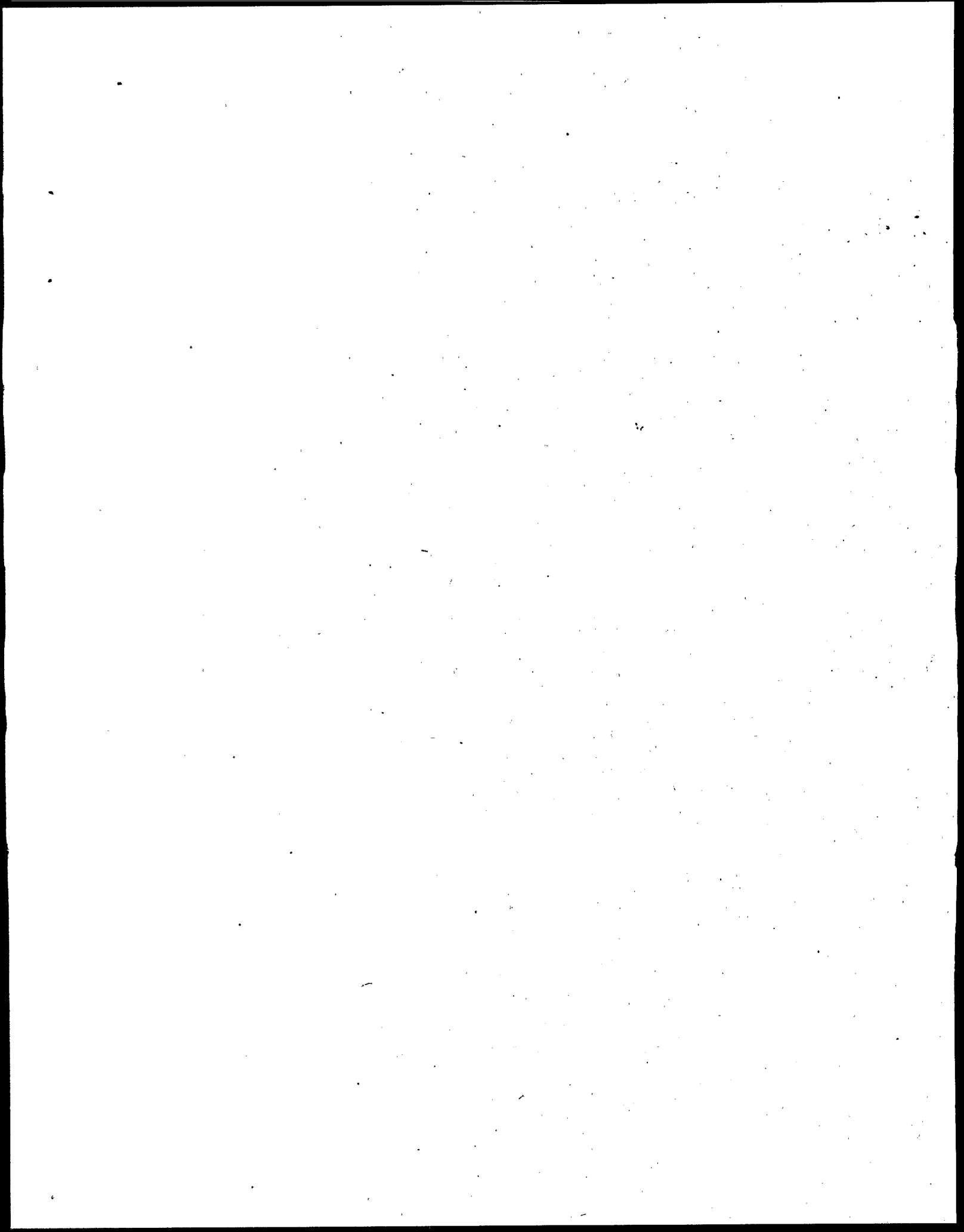
Table A-5. Continued

STATE	NAME ^a	WIDTH ^b	SHADING/STREAM TEMPERATURE ^b	LOGGING REQUIREMENTS ^c	APPLICABILITY ^d
Oregon	RMA	Variable	Retain 75% shade and 50% canopy		Class I waters
Pennsylvania	FS	50' min; varies by slope			P
Rhode Island	FS	25' min; varies by slope			Streams
South Carolina	SMZ				
Tennessee	SMZ	25' min; varies by slope	Retain 50-75% canopy shading stream	Selective	P
Texas	SMZ	50'	Evenly retain 50% crown cover or 50 sq ft of basal area/acre		P
Vermont	PS	50' min; varies by slope		Selective; must maintain log transport machinery outside 25'	Streams; water bodies
Virginia	SMZ	50' min; varies based on slope and water type	Evenly retain 50% crown cover or 50 sq ft of basal area/acre	Partial harvesting	P; lakes; ponds
Washington	RMZ	Charts/equations provided to calculate width	Methods provided for determining adequate shade; temperature prediction model available	Retain \geq 50% trees live and undamaged; specifications in Rules	Type 1, 2, or 3 Waters
West Virginia	FS	25' min			
Wisconsin	SMZ			Uncut or partial cut	
Wyoming	BZ	Varies based on slope (0'-1300')			

^a BS = Buffer Strip; BZ = Buffer Zone; FS = Filter Strip; PS = Protective Strip; RA = Riparian Area; RMA = Riparian Management Area; RMZ = Riparian Management Zone; SMZ = Streamside Management Zone; SPZ = Streamside Protection Zone; SS = Shade Strip; and WLPZ = Watercourse and Lake Protection Zone.

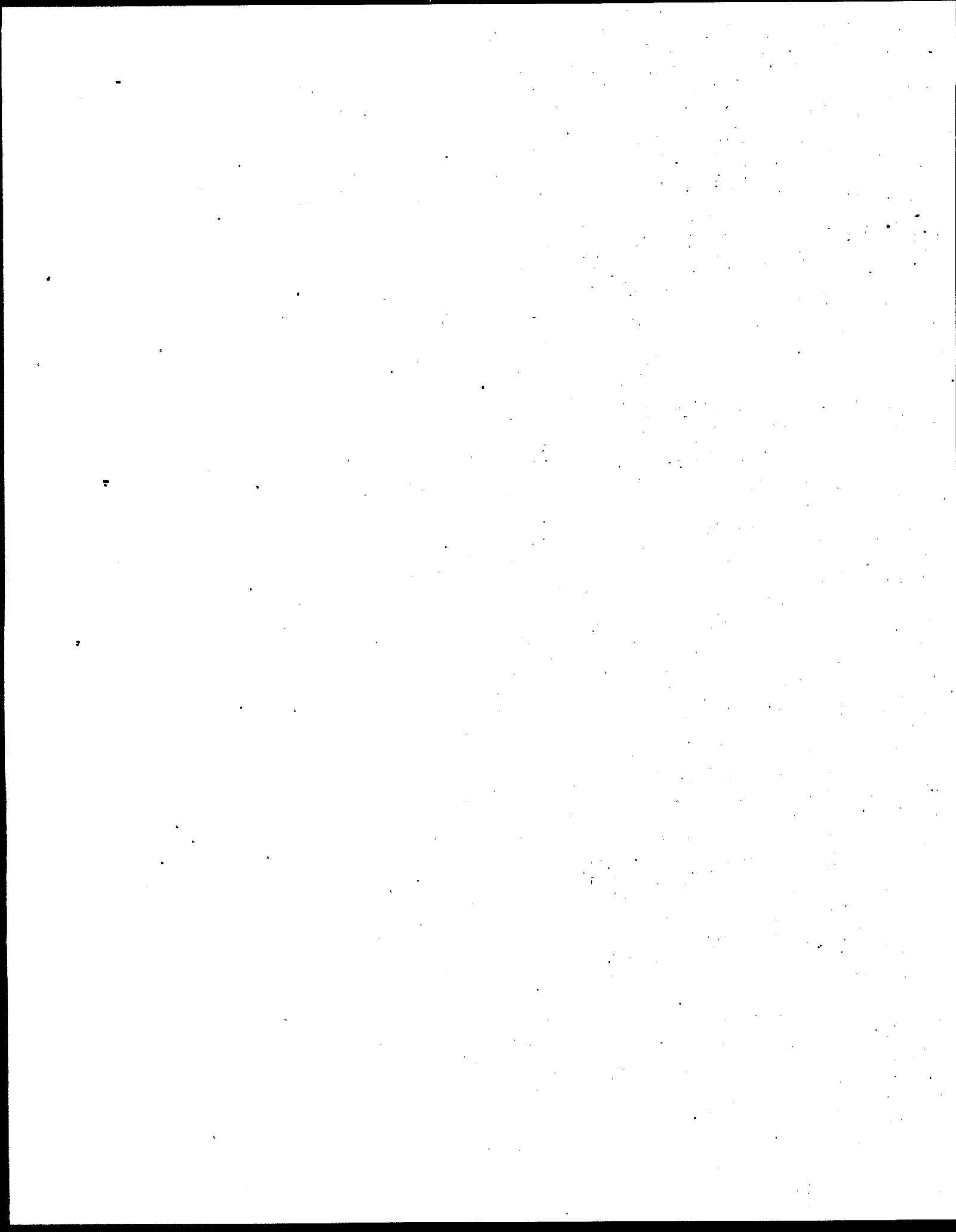
^b P = Perennial Stream and I = Intermittent Stream.

^c CAH = Coldwater Aquatic Habitats



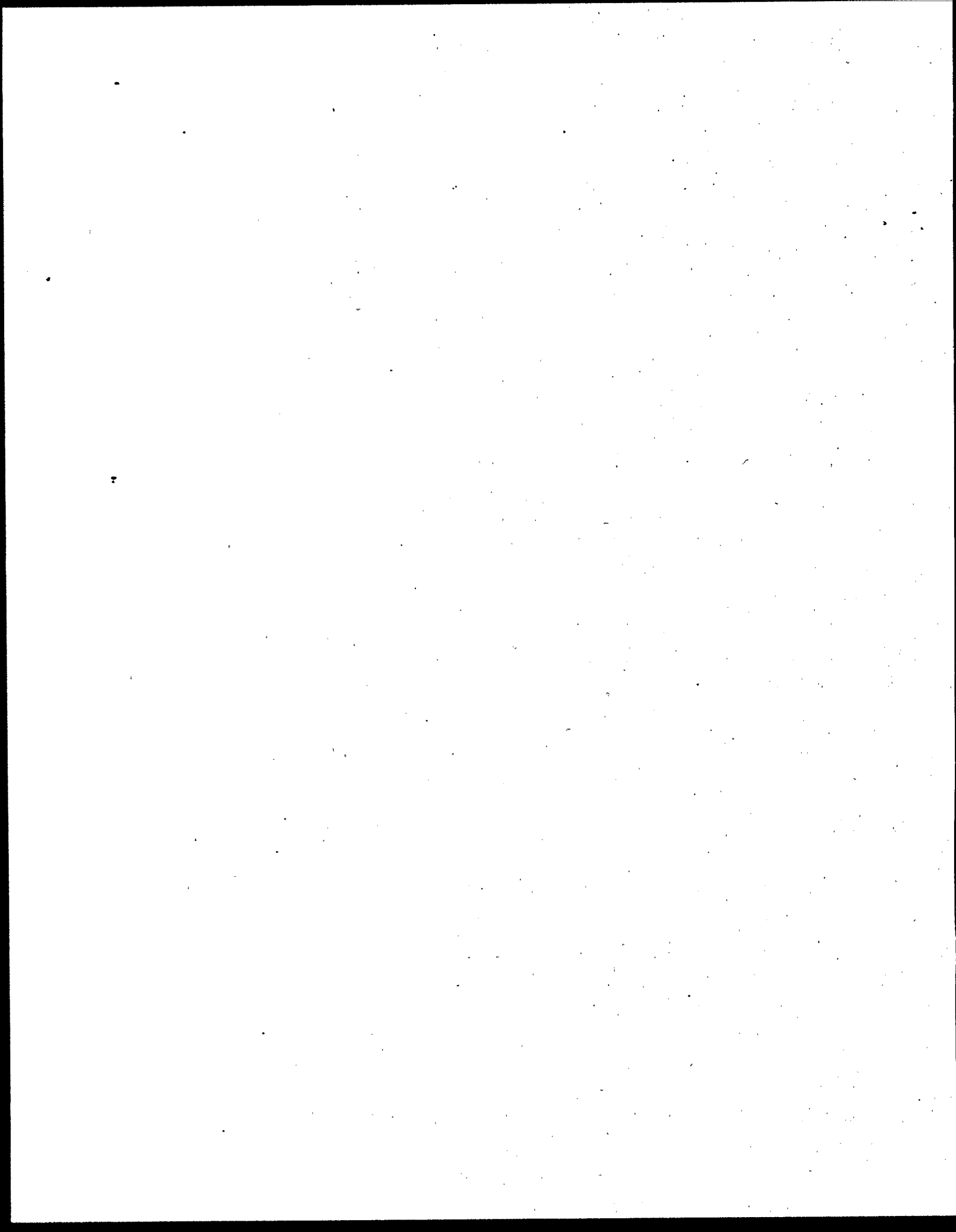
APPENDIX B

**INFORMATION OBTAINED FROM
THE NATIONAL ASSOCIATION OF STATE FORESTERS**



Contents

State Contacts Obtained Through NASF	B-1
Technology Transfer Information Obtained by NASF Survey	B-3



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Technology Transfer Information Obtained by NASF Survey - Updated 1/93

ALABAMA

Manuals/Books	<i>Alabama's Best Management Practices for Forestry (1989)</i> ; it will be revised by end of 1993.
Brochures	<i>Alabama's Best Management Practices for Forestry (1990)</i> ; it is a condensed pocket guide version of the full 1989 manual
Posters/Displays	<i>Use BMPs to Protect Water Quality</i>
Video/Slide Programs	Currently developing a BMP video; have developed a 15 minute and a 35 minute slide presentation that provides a general overview of BMPs
Training/Workshops	Conducted a 5-day BMP training session at the request of specific forest products companies, and have performed more than 55 shorter BMP presentations to both forestry and non-forestry audiences
Other Educational Material	<i>Our Treasured Forests</i> , Alabama Forestry Commission's stewardship magazine includes articles that relate to water quality

ALASKA

Manuals/Books	Will print by end of 1993
Brochures	Will print <i>Forest Practices</i> by end of 1993; it will emphasize education, prevention, and enforcement
Posters/Displays	Will develop by end of 1993
Video/Slide Programs	Will develop by end of 1993
Training/Workshops	Training on implementation of Forest Practice Regulations and enforcement, held in Anchorage and Ketchikan (May, 1992)
Other Educational Material	None

ARIZONA

Manuals/Books	None
Brochures	None
Posters/Displays	None
Video/Slide Programs	None
Training/Workshops	None
Other Educational Material	Natural resource conservation workshop for Arizona youth; Project Learning Tree

ARKANSAS

Manuals/Books	<i>Best Management Practices Guidelines for Silviculture</i> and <i>A Guide to Better Forestry Practices and Water Quality</i> are for use by foresters, loggers, landowners, and consultants; <i>A Guide to Better Logging and Better Water Quality</i> is targeted primarily for loggers
Brochures	None
Posters/Displays	None
Video/Slide Programs	Developed a slide presentation entitled <i>Best Management Practices Guidelines</i> for training purposes
Training/Workshops	Arkansas Forestry Commission has conducted training since 1982; current training is predominately one-on-one sessions, but they still occasionally conduct group sessions
Other Educational Material	Both Forest Management Plans and Forest Stewardship Plans address water quality and BMP implementation

CALIFORNIA

Manuals/Books	<i>California Forest Practice Rules</i> is updated annually and is intended for timber operators, but is used by licensed foresters, attorneys and others
Brochures	An extensive selection of publications are available from the California Department of Forestry and Fire Protection that address various forestry issues and regulations and assist operators and landowners to comply with the Forest Practice Rules
Posters/Displays	None
Video/Slide Programs	Developed videos for timber operators that address erosion control, streamside protection, road building, yarding, felling, bucking, silvicultural systems and public confidence
Training/Workshops	<i>Training for Licensing as Timber Operators</i> is a six-hour course presented every 6 weeks; <i>Geology and Hydrology for Resource Professionals</i> (3/88); <i>Road Design Workshop</i> (3/88); <i>Erosion Control and Slope Protection</i> (3/88); <i>Cumulative Watershed Effects Short Course</i> (10/88); <i>Harvesting Our Trees While Retaining Our Fish</i> (4/89); <i>Roads and Landings, Design, Layout, and Construction</i> (3/90); Workshop on site prep and erosion control (5/90); <i>Cumulative Impact Training</i> for foresters (9/91); <i>Forest Practice Enforcement</i> (11/91); <i>Foundation Silviculture</i> 6/92 and (7/92); <i>Archeology Training for Resource Professionals</i> (26 completed, 8 in 1992)
Other Educational Material	None

COLORADO

Manuals/Books	None
Brochures	None
Posters/Displays	None
Video/Slide Programs	None
Training/Workshops	Through the Stewardship program, BMPs for silviculture will be included in training for resource management professionals, landowners, and forest industries
Other Educational Material	None

CONNECTICUT

Manuals/Books	<i>A Practical Guide for Protecting Water Quality While Harvesting Forest Products</i> (1990)
Brochures	Yes
Posters/Displays	None
Video/Slide Programs	None
Training/Workshops	Conducted training sessions in 1981, 1982 and 1990
Other Educational Material	None

DELAWARE

Manuals/Books	The State is currently preparing a BMP manual
Brochures	Preparing a brochure to compliment video entitled <i>BMPs for Loggers</i>
Posters/Displays	A display that demonstrates the value of BMPs in forestry and the relationship of trees and water quality
Video/Slide Programs	Two 15 minute videos entitled <i>BMPs for Loggers</i> and <i>Pre-harvest Planning for Landowners</i>
Training/Workshops	Will be conducting training in Fall 1992/Winter 1993 for foresters, industry personnel, staff, conservation district, and Delaware Department of Natural Resources and Environmental Control when the BMP manual is formalized
Other Educational Material	None at present, but future projects include wetland demonstration areas and supporting educational materials

FLORIDA

Manuals/Books	<i>Silvicultural Best Management Practices Manual</i> (1991); revised manual will be printed in 1993
Brochures	May print some after BMP manual revision is completed
Posters/Displays	Posters that address BMPs for silviculture
Video/Slide Programs	Developing two videos entitled <i>Managing Florida's Forested Wetlands</i> and <i>BMP Implementation</i>
Training/Workshops	Have conducted 11 BMP workshops as of August 1992 and 3 more are scheduled for Fall 1992; Workshops are designed for loggers and utilize BMP materials, field trips, and slide presentations.
Other Educational Material	None

GEORGIA

Manuals/Books	<i>Recommended Best Management Practices for Forestry in Georgia (1988); Best Management Practices for Forested Wetlands in Georgia (1990)</i>
Brochures	<i>BMPs for Road Construction and Timber Harvesting Practices in Georgia; BMPs for Site Preparation, Reforestation and Chemical Treatments in Georgia; BMPs along Trout Streams in Georgia</i>
Posters/Displays	Tabletop display that addresses forest water quality by comparing photos of acceptable and unacceptable forest management practices
Video/Slide Programs	Video entitled <i>BMP is Not a Four Letter Word</i> ; slide program entitled <i>Forest Water Quality</i> ; developing a video entitled <i>Environmental Firebreak Plowing Using BMPs</i>
Training/Workshops	Conducted workshop <i>BMPs for Georgia's Forested Wetlands</i> on April 2-4 and 8-10, 1991 targeting professional foresters, 506 attended; conducted workshop <i>BMPs for Georgia's Forested Wetlands</i> on December 3, 4, and 7, 1991 targeting landowners, 100 attended; 12 workshops on BMPs for State Fish and Game personnel; will conduct workshops upon request for timber companies, and their foresters and loggers
Other Educational Material	BMP bumper sticker

IDAHO

Manuals/Books	<i>Rules and Regulations Pertaining to the Idaho Forest Practices Act Title 38, Chapter 13, Idaho Code.</i>
Brochures	Preparing brochure entitled <i>BMPs and Water Quality</i>
Posters/Displays	A forest stewardship display highlights BMPs as an integral component of stewardship
Video/Slide Programs	Video scheduled for late 1992 or early 1993 entitled <i>Forest Water Quality</i> ; it is a joint Stewardship, Forest Practices Act, and Extension project
Training/Workshops	Series of state-wide workshops conducted each spring; topics include Forest Practices Act, BMPs, fish habitat, water quality, and stream ecology
Other Educational Material	A newsletter type publication entitled <i>State Forester Forum</i> focuses upon specific subjects, including BMPs, forest management, insects, disease, etc.

ILLINOIS

Manuals/Books	None
Brochures	None
Posters/Displays	None
Video/Slide Programs	None
Training/Workshops	Training workshop for loggers 10/89; provided training to SCS and SWCD staff 1990-1992; developing training program for loggers by 1993 to be used on a continuous basis
Other Educational Material	None

INDIANA

Manuals/Books	<i>Logging Roads and Skid Trails: A Guide for Soil Protection and Timber Access</i>
Brochures	<i>Best Management Practices: Protecting the Woods While Harvesting; Woodlands Make Poor Pastures</i>
Posters/Displays	None
Video/Slide Programs	Video entitled <i>Harvesting with the Forest</i> ; anticipate developing a forestry water quality management video
Training/Workshops	Conducted workshop (11/89) at a recently harvested site that demonstrated proper construction and placement of water bars using skidders, dozers, farm tractors, and hand construction, and demonstrated seeding, fertilizing and mulching operations; plan to conduct workshop on skidder operation training to minimize soil and residual stand damage and increase efficiency; comprehensive logger training scheduled for 1993 that will include silvicultural BMPs
Other Educational Material	BMPs are standard part of timber sale contracts on State lands; developing a contract with BMPs for private landowners

IOWA

Manuals/Books	None
Brochures	None
Posters/Displays	None
Video/Slide Programs	None
Training/Workshops	None
Other Educational Material	<i>Forest Land Stewardship - Cost Share Assistance; Converting CRP to Trees; Iowa Tree Planting Guide; Grazing Iowa Woodlands; Forestry and Ag Diversification; Harvesting and Regenerating Upland Woodlands; Management of Floodplain Forests; Environmental Effects of Woody Vegetation</i>

KANSAS

Manuals/Books	None
Brochures	Developing brochures that will address comprehensive management of riparian and wetland forests for water quality and other multiple benefits
Posters/Displays	None
Video/Slide Programs	Slide program entitled <i>Riparian Forest Management</i> that discusses forestry and water quality
Training/Workshops	Planning committee is developing a training session on riparian forest management
Other Educational Material	None

KENTUCKY

Manuals/Books	<i>Kentucky Forest Practice Guidelines for Water Quality Management (1992)</i>
Brochures	Developing <i>Kentucky Pocket Guide to BMPs</i>
Posters/Displays	None
Video/Slide Programs	Video and slide-tape program developed as an overview for BMP implementation; video entitled <i>Kentucky Forest Practice Guidelines for Water Quality Management</i>
Training/Workshops	Intensive training for loggers on the need and use of BMPs is planned
Other Educational Material	None

LOUISIANA

Manuals/Books	<i>Recommended Forestry Best Management Practices for Louisiana (1988)</i>
Brochures	None
Posters/Displays	None
Video/Slide Programs	Two videos entitled <i>Let's Clean Up Our Act</i> and <i>Leading the Way with BMPs</i>
Training/Workshops	Seven state-wide sessions conducted during the summer of 1992
Other Educational Material	None

MAINE

Manuals/Books	<i>Erosion and Sediment Control Handbook for Maine Timber Harvesting Operations Best Management Practices (1991); Best Management Plans (1992); Lesson Plan for BMPs (1992)</i>
Brochures	Developing a condensed version of BMP manual; developing lesson plans for BMPs for use by any trainer
Posters/Displays	None
Video/Slide Programs	None
Training/Workshops	Over 450 loggers trained through the Certified Loggers Program; training sessions by the York and Cumberland Soil and Water Conservation Districts
Other Educational Material	None

MARYLAND

Manuals/Books	<i>Maryland's Guide to Forest Harvest Operations and Best Management Practices</i> (1992)
Brochures	<i>Forest Harvest Access Practices (Pocket Guide)</i> and <i>How to Get Logging Permits Approved in Maryland's 23 Counties</i> - these documents are being revised and combined into a single document; <i>Soil Erosion and Sediment Control Guidelines for Forest Harvest Operations in Maryland</i>
Posters/Displays	<i>Monocacy River Watershed Project; Susquehanna River Watershed Project; Logging in Non-Tidal Wetlands</i>
Video/Slide Programs	<i>Sediment Control Training for Forest Harvest Operations</i> ; developing <i>Best Management Practices for Logging on the Delmarva</i>
Training/Workshops	Workshops for loggers, landowners, foresters, wildlife biologists, etc. have been conducted since 1984; regional training teams have been established and will conduct at least 8 workshops per year for logger training, including BMPs
Other Educational Material	Stewardship Incentive Programs #5 <i>Soil and Water - Erosion Control</i>

MASSACHUSETTS

Manuals/Books	<i>Massachusetts Best Management Practices Timber Harvesting Water Quality Handbook</i> ; will update as Forest Cutting Practices Act regulations are revised
Brochures	Stewardship brochures
Posters/Displays	Displays at various fairs and field days on BMPs as part of overall forest management program
Video/Slide Programs	Currently developing
Training/Workshops	Conducted three workshops state-wide involving slide show on stream crossing study by consultant, slide show on BMPs by USFS representative, and field visits to good and bad BMP situations (Summer 1989); vernal pool workshops involving slides of wetland wildlife habitat and field visits to vernal pools to discuss BMPs (Summer 1990); planning logging and wetland workshops for 1993
Other Educational Material	None

MICHIGAN

Manuals/Books	<i>Water Quality Management Practices on Forest Land</i>
Brochures	None
Posters/Displays	None
Video/Slide Programs	Video entitled <i>Michigan's Dynamic Forest</i> , which discusses silvicultural practices of major forest types and various public values; not a water quality video
Training/Workshops	Thirteen BMP workshops conducted Fall 1990 through Spring 1992 for loggers, landowners, industry, consultants, State Forester's staff, and other resource managers
Other Educational Material	Stewardship program includes water quality emphasis

MINNESOTA

Manuals/Books	<i>Water Quality in Forest Management: Best Management Practices in Minnesota</i> (1989); the DNR/Forestry in cooperation with the forestry community and water quality agencies will develop by June 1993 wetland BMPs to implement the MN Wetlands Conservation Act of 1991
Brochures	<i>Best Management Practices for Water Quality in Urban, Agricultural and Forestry Applications</i> is a general brochure for landowners; <i>Water Related Land Use Programs: Shoreland Management, Wild and Scenic Rivers, Floodplain Management</i> is for landowners in shoreland areas; <i>A Guide for Buying and Managing Shoreland</i> is for zoning administrators and landowners in shoreland areas
Posters/Displays	None
Video/Slide Programs	<i>Best Management Practices in Minnesota Forestry</i> is an overview of BMPs for loggers, landowners and resource managers based on the forestry BMP guidebook
Training/Workshops	400 loggers attended 13 workshops (Spring 1991); 400 natural resource professionals attended 10 workshops (Fall 1991); 6+ workshops are planned for Spring 1993 for woodland advisors, lake advocates and county woodland committees
Other Educational Material	<i>Woodland Stewardship</i> plans contain information on water quality protection and include a copy of the BMP guidebook; DNR/Forestry BMP team is available to conduct education programs; BMP monitoring program is in place to measure and evaluate application and effectiveness of BMPs -- inspecting 120+ sites in 1992 and the audits are to be used as field training for landowners

MISSISSIPPI

Manuals/Books	<i>Mississippi's Best Management Practices for Wetlands; Silvicultural Best Management Practices for MS; Mississippi's Best Management Practices Handbook</i>
Brochures	Yes
Posters/Displays	Dept. of Environmental Quality has developed a display about NPS pollution
Video/Slide Programs	Video entitled <i>Best Management Practices</i>
Training/Workshops	Yes
Other Educational Material	

MISSOURI

Manuals/Books	<i>Missouri Watershed Protection Practices: Management Guidelines for Maintaining Forested Watersheds to Protect Streams</i> (1990)
Brochures	None
Posters/Displays	None
Video/Slide Programs	Developed a slide series on stream management, but it is no longer in use
Training/Workshops	Annual standard training provided to new foresters
Other Educational Material	None

MONTANA

Manuals/Books	<i>Montana Forestry Best Management Practices</i>
Brochures	<i>Forestry BMPs—Forest Stewardship Guidelines for Water Quality</i> ; developing summary of forest practices by early 1993
Posters/Displays	Poster - <i>Forestry and Water Quality</i> ; during Winter 1992/1993, creating 3 displays for use at fairs and other public gatherings that will address BMPs, SMZs and good vs bad practices
Video/Slide Programs	Slide/tape series - <i>Forestry and Water Quality</i> ; Montana Logging Association slides on roads and SMRs with narrative; developing video on BMPs and SMZs; plan to develop a PSA on logging and water quality
Training/Workshops	Series of BMP workshops for loggers and landowners sponsored by MT Logging Association (1989-1990); East MT workshop for landowners and industry (7/90); BMP field training for Service foresters (Fall 1990); road engineering training for service and State lands forester (Winter/Spring 1990); Workshop on SMZs (Summer/Fall 1991); field soils training with relations to logging, BMPs, and SMZs (Fall 1991); both field and informational session on SMZ law (Spring/Summer 1992); workshops planned for Fall 1992 and Winter 1993
Other Educational Material	None

NEBRASKA

Manuals/Books	None
Brochures	None
Posters/Displays	None
Video/Slide Programs	None
Training/Workshops	None
Other Educational Material	None

NEVADA

Manuals/Books	None
Brochures	<i>Incline Village/Crystal Bay Defensible Space Handbook</i> - reduce wildfire threat compatible with other environmental values, especially water quality
Posters/Displays	None
Video/Slide Programs	None
Training/Workshops	None
Other Educational Material	None

NEW HAMPSHIRE

Manuals/Books	<i>Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire</i>
Brochures	Foresters pocket field guide for loggers; BMP book for landowners
Posters/Displays	None
Video/Slide Programs	None
Training/Workshops	Workshops held in 1990; Wetlands evaluation workshop for foresters (5/92); additional workshops planned for 1993
Other Educational Material	None

NEW JERSEY

Manuals/Books	Developing a wetlands forestry manual for foresters and forest landowners
Brochures	None
Posters/Displays	None
Video/Slide Programs	None
Training/Workshops	Workshop <i>Freshwater Wetlands: Identification and Regulation</i> to provide training for foresters (9/92)
Other Educational Material	None

NEW MEXICO

Manuals/Books	<i>New Mexico Forest Practices Guidelines; Water Quality Protection Guidelines for Forestry Operations in New Mexico; Reducing Erosion from Unpaved Rural Roads in New Mexico</i>
Brochures	None
Posters/Displays	None
Video/Slide Programs	Slide presentation <i>NM State Forestry 208 Program</i> discusses ways to reduce nonpoint silvicultural pollution
Training/Workshops	Have held many formal and informal sessions for loggers, landowners, and State Forestry staff since 1983
Other Educational Material	None

NEW YORK

Manuals/Books	Will publish by 1993; developing field guide entitled <i>Choosing and Using BMPs</i>
Brochures	<i>Timber Harvesting Guidelines for New York; A Clean Harvest; New York State Cooperating Timber Harvester Program</i>
Posters/Displays	None
Video/Slide Programs	None
Training/Workshops	Three or four workshops are conducted annually as part of the Cooperating Timber Harvesters Program; at least one workshop per year is specifically on BMPs and erosion prevention
Other Educational Material	None

NORTH CAROLINA

Manuals/Books	<i>North Carolina Forestry Best Management Practices Manual (1989); North Carolina Forest Practice Guidelines Related to Water Quality (1989); Pocket Guide to Forest Practice Guidelines (1990)</i>
Brochures	<i>Forestry Leaflets: Summary of Performance Standards; Forestry Leaflets: Streamside Management Zones; Forestry Leaflets: Suggested Provisions for Timber Sale Contracts; Forestry Leaflets: Becoming a Forest Steward in North Carolina</i>
Posters/Displays	Display entitled <i>Best Management Practices</i> composed of color pictures showing examples of BMPs
Video/Slide Programs	Two videos entitled <i>SMZ - Streamside Management Zones and Maintaining Your Exemption from SPCA Paperwork</i>
Training/Workshops	State Forester and Extension has presented programs together and separately; industry groups, consulting foresters, and State Forestry personnel have received BMP training
Other Educational Material	None

NORTH DAKOTA

Manuals/Books	None
Brochures	Brochure by ND State Health Department on ND Rules and Regulations (ND Standards for Water Quality)
Posters/Displays	None
Video/Slide Programs	Numerous videos and PSA produced by ND State University Extension; <i>Clean Water - Clean Choices</i> by the National Association of Soil Conservation Districts
Training/Workshops	ND State University Extension sponsors an annual symposium on water quality for agencies and the general public
Other Educational Material	Numerous publications by ND State University Extension on water quality; a speaker's bureau was developed by the North Dakota Water Quality Task Force in 1990 and its members are available to speak on water quality issues

OHIO

Manuals/Books	<i>BMP's for Erosion Control on Logging Jobs</i>
Brochures	<i>Planting Filter Strips to Improve Water Quality</i>
Posters/Displays	Will develop <i>Forest Filter Strips</i> in 1993
Video/Slide Programs	None
Training/Workshops	<i>BMPs in Forestry</i> (4/90); <i>Best Management Practices Workshop for Loggers</i> (11/90); BMP trainers workshop scheduled for 2/93
Other Educational Material	None

OKLAHOMA

Manuals/Books	<i>Forest Manager's Guide for Water Quality Management in Oklahoma</i>
Brochures	Developing a pocket guide on forestry BMPs
Posters/Displays	None
Video/Slide Programs	Video entitled <i>Logging BMPs and Water Quality</i> ; developing video about road rehabilitation
Training/Workshops	Workshops planned for 1993 - will emphasize roads and logging
Other Educational Material	

OREGON

Manuals/Books	<i>Forest Practice Rules</i> (1991)
Brochures	<i>Waterbars; Road Maintenance; Ditch Relief Culverts; Riparian Protection</i>
Posters/Displays	<i>The Oregon Practices Act</i> is a display of the primary topics of the Forest Practice Rules
Video/Slide Programs	<i>The Man and the Machine</i> is a slide program and script promoting skidding practices that protect water quality
Training/Workshops	<i>Slope Stability</i> (1984); <i>Riparian Protection</i> (1987); since 1990, training efforts have focused on explaining and implementing the requirements of the Forest Practices Act, particularly rules related to sensitive bird sites, threatened and endangered species, significant wetlands, clearcut size and spacing, snag, live tree and downwood retention, and scenic corridor management; planned for 1993 is <i>Classification and Protection of Waters of the State</i>
Other Educational Material	Oregon State University Forestry Extension has developed an enormous selection of publications and videos

RHODE ISLAND

Manuals/Books	Currently developing and will publish by 1993
Brochures	<i>Planning Wetlands - A Landowner's Responsibility to Know</i> , a brochure that will detail BMPs for silvicultural operations in wetland areas
Posters/Displays	None
Video/Slide Programs	None
Training/Workshops	Planning wetland workshops to educate the forestry community on wetland BMPs
Other Educational Material	<i>Rhode Island Stewardship Directory</i>

SOUTH CAROLINA

Manuals/Books	<i>Voluntary Forest Practice Guidelines for South Carolina</i> (1988) - currently being revised; <i>Best Management Practices's for South Carolina's Forested Wetlands</i> ; <i>A Survey of Voluntary Compliance of Forestry Best Management Practices</i>
Brochures	<i>Let's Lead the Way with Best Management Practices; Forestry BMPs . . . A Woodland Owner's Guide to Good Stewardship</i>
Posters/Displays	None
Video/Slide Programs	Videos entitled <i>Let's Clean Up Our Act</i> and <i>Let's Lead the Way</i> ; slide program entitled <i>General BMP's, Wetland BMP's, and South Carolina's 1991 Silvicultural NPS Program</i>
Training/Workshops	BMP awareness for loggers and procurement foresters at 14 locations (1989); BMP awareness for landowners at 20 locations (1992); will offer BMP interpretation meetings statewide when revised BMP manual is published
Other Educational Material	None

SOUTH DAKOTA

Manuals/Books	Preparing BMP manual, but final publication date not established
Brochures	Will develop once BMPs are adopted
Posters/Displays	None
Video/Slide Programs	Currently developing video
Training/Workshops	None
Other Educational Material	None

TENNESSEE

Manuals/Books	<i>Best Management Practices for Silvicultural and Other Forest Activities in Tennessee</i> (1989); <i>Best Management Practices for Protection of the Forested Wetlands of Tennessee</i> (1990); <i>Logger's Guide to Forestry BMPs</i> ; <i>A Nonpoint Source Management Plan for Forestry Activities in Tennessee</i> ; <i>BMPs and Timber Harvesting</i>
Brochures	<i>Clean Water from Tennessee's Forests</i> ; <i>Forestry BMPs Work: Pickett State Forest</i> ; <i>BMP Effectiveness Study</i>
Posters/Displays	Tabletop display for meetings on BMPs
Video/Slide Programs	Two slide-tape presentations entitled <i>BMPs for Forestry in Tennessee</i> and <i>Forestry and Water Quality in Tennessee</i> ; developing a video discussing BMPs for timber harvesting
Training/Workshops	Conducted workshops and field tours discussing BMPs and their implementation
Other Educational Material	Stewardship Program materials; <i>A Guide to Forest Management and Conservation Biology</i> is for use in elementary schools

TEXAS

Manuals/Books	<i>Texas Best Management Practices for Silviculture</i> (1990); currently being revised as <i>Texas Forestry Best Management Practices</i> scheduled to be printed 12/92
Brochures	<i>Silvicultural Practices</i> is an overview of NPS issues and Texas Silvicultural BMPs; currently being revised as <i>Forestry Best Management Practices for Water Quality</i>
Posters/Displays	Full-sized exhibit entitled <i>BMPs in the Log Woods</i> that displays pictures of good and bad practices.
Video/Slide Programs	Slide presentation entitled <i>Best Management Practices: A Common Sense Solution to Water Pollution</i> that is an overview of NPS issues and BMPs
Training/Workshops	43 workshops conducted between 12/90 and 9/92 for landowners, company foresters and loggers, civic groups, etc.
Other Educational Material	

UTAH

Manuals/Books	None
Brochures	In the process of developing brochures pertaining to forestry BMPs and water quality that are scheduled for publication end of 1993
Posters/Displays	None
Video/Slide Programs	None
Training/Workshops	In the process of developing a series of workshops in conjunction with the College of Natural Resources, Cooperative Extension at Utah State University
Other Educational Material	None

VERMONT

Manuals/Books	<i>Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont</i> (1987); <i>Wetland Rules and Regulations: What They Mean to Your Logging Operation in Vermont</i>
Brochures	Brochure to accompany the video
Posters/Displays	None
Video/Slide Programs	Video entitled <i>Plank Skid-trail Bridge Construction</i> ; slide program on silviculture for Vermont loggers
Training/Workshops	Series of three workshops to train loggers in 1989; planning another series of workshops for 1993
Other Educational Material	

VIRGINIA

Manuals/Books	<i>Forestry Best Management Practices for Water Quality in Virginia</i> (1989)
Brochures	<i>Forest Landowner and Water Quality; Debris in Stream Law; Landowners, Loggers, Foresters Use BMPs</i> , which describes 5 main BMP problems; a series of brochures on main BMP work areas
Posters/Displays	Prepared 6-panel exhibits for each region that show primary watersheds and BMPs; special exhibits created for the East Coast Logging Expo in Richmond May 1988 and 1990
Video/Slide Programs	Three videos entitled <i>Managing Mountain Forests for Clean Water</i> (25 min), <i>Impact of BMP Regulations on Maryland Logging</i> (10 min), and <i>BMPs for Logging</i> (15 min); slide show entitled <i>Forestry Program in Virginia</i>
Training/Workshops	BMP training meetings statewide from 11/88-3/90, 1,990 attended; 8 regional field demonstrations (10/89), 500 attended; field trip for VA Environmental Staff on Wetlands and BMPs (4/89); wetland delineation workshop for VA DOF (9/91); wetlands delineation workshop planned for Spring 1993; training module on BMP installation planned for Summer 1993
Other Educational Material	Stewardship information packet on water quality; two page summary for VA legislature (9/92); and a door mounted BMP inspection form for loggers (11/92)

WASHINGTON

Manuals/Books	<i>Forest Practices Rules and Regulations; Board Manual and Guidelines; Forest Practices Act</i>
Brochures	<i>Fact Sheets and Heads-Up</i> describe changes to the Forest Practice Rules and provide a general summary of new rules; <i>Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska</i>
Posters/Displays	Displays on forest stewardship, activities that impact the environment, and mitigation or protective measures
Video/Slide Programs	Video entitled <i>Wall-based Channels</i> that describes fish habitat off main channels
Training/Workshops	Workshops on shade requirements, wildlife reserve tree requirements, wetland delineation, even-aged harvest size, class IV forest practices, and watershed analysis have been conducted; scheduled training includes sediment mitigation, water temperature modeling, and procedures for voluntary watershed agreements
Other Educational Material	

WEST VIRGINIA

Manuals/Books	<i>Clean Streams Handbook for Loggers; Clean Streams Handbook for Landowners; Guidelines for Controlling Soil Erosion and Water Pollution on Logging Operations - a technical pocket guide; Silvicultural Water Quality Management Plan; Logging Sediment Control Act</i>
Brochures	<i>Keeping Mud Out of the Streams; Forest Owners and Logging Roads</i>
Posters/Displays	A display entitled <i>Planning the Logging Operation</i> and a poster entitled <i>Managing Your Woodlot</i>
Video/Slide Programs	A BMP slide-tape presentation; videos entitled <i>Building Roads, Selling Timber, and Forest and Water</i>
Training/Workshops	Since the mid 1970's, the Division of Forestry in cooperation with the WVU Extension, Fernow Experimental Forest, and the WV Forestry Association has conducted BMP and silvicultural workshops for industry and consultants; conducted up to 30 workshops a year for 1989-1991; 100 workshops scheduled for fiscal year 1992-93
Other Educational Material	

WISCONSIN

Manuals/Books	<i>Forest Practice Guidelines for Wisconsin (1990); creating a task force of private and public interest groups to revise this BMP manual by 12/93</i>
Brochures	None
Posters/Displays	None
Video/Slide Programs	None
Training/Workshops	Forest practices and water quality workshop for foresters sponsored by the Lake States Forestry Alliance (5/27-29/92); a forest roads workshop for loggers, foresters and contractors that will be conducted both indoors and outdoors (10/20-21/92)
Other Educational Material	The above mentioned task force will develop an educational approach and a compliance monitoring team

WYOMING

Manuals/Books	<i>Best Management Practices for Silviculture - Second Draft</i>
Brochures	<i>Clean Water Ways</i> is an NPS newsletter; <i>Wyoming Hydrogram</i> is a newsletter published by Wyoming's Water Resources Center
Posters/Displays	None
Video/Slide Programs	None
Training/Workshops	1990 state-wide water quality conference that was geared to landowners and land managers who work towards implementing conservation practices to improve water quality
Other Educational Material	<i>Forest Stewardship: The Conservation of Wyoming's Forest Inheritance</i>