

**Comparison of Southern State Best Management Practices  
Used to Protect Water Quality during Forestry Operations**

by

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Research Summary

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This component of the study titled *Integrating Economic and Ecological Models Across Spatial Scales to Assess Aquatic Species Vulnerability to Timber Harvest and Land Use Change in Freshwater Streams of the Southeastern United States: Best Management Practices and Timber Supply Impacts* compares the content and the effectiveness in implementing forestry best management practices (BMPs) for southern states for water quality protection during forestry operations.

## **I. Introduction**

Best management practices (BMPs) are methods by which states can meet water quality goals for nonpoint pollution sources such as forestry. All 50 states have adopted their own forestry BMPs (National Association of State Foresters [NASF] 2001). BMPs for forestry are used to protect against water pollution resulting from forestry activities. Some states require the implementation of silvicultural NPS controls such as BMPs, but most states have voluntary control programs (National Council of the Paper Industry for Air and Stream Improvement, Inc. [NCASI] 1994). Specifically, most NPS control programs in the South are voluntary.

By allowing for voluntary implementation of forestry BMPs there is no certainty that landowners are following the guidelines set by these rules. In order to determine whether or not forest landowners are implementing BMPs states need to monitor forestry site activity. How implementation rates are measured and defined varies between states since all states develop their own forestry BMPs and compliance monitoring programs. Ellefson et al. (2001) define compliance monitoring as “the systematic gathering of information to determine whether forest practice guidelines or rules are actually being applied in the intended manner by landowners and timber harvesters”. Measurement of

implementation by each state depends on which silvicultural practices the state includes in its BMP manual and what criteria must be met in order for the practices to be deemed implemented correctly. Differences in state BMPs and how states define and measure implementation makes comparison between states challenging.

The National Council of the Paper Industry for Air and Stream Improvement (NCASI), researchers at the University of Kentucky, the USDA Forest Service Law and Economics Research Work Unit, and the US EPA in conjunction with the USDA Forest Service have written papers and articles comparing states' BMPs and water quality laws. In order to evaluate the development of BMPs and compliance monitoring for implementation for southern states, this report will attempt to synthesize the information from these and other documents and include summary of relevant water quality laws and information from the states BMPs.

Thirteen states will be considered as southern states for the purpose of this report: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia. The report will consist of several sections: (1) Water quality laws, (2) Development of forestry best management practices, (3) Outline and comparison of BMPs between states, and (4) Implementation rates for BMP practices.

## **II. Water Quality Law**

To better understand why and how BMPs were developed, a brief look at water quality law and the BMP development process is necessary. The development of BMPs may be traced back to legislation that established the National Forest system. One of the

major reasons for establishment of a National Forest system was to protect water supplies. It was during this time that forests were being realized as important sources of high quality water (NCASI 1999).

The catalyst that actually led to the development of state water quality protection programs for forestry is the Clean Water Act (CWA) of 1972 and 1977. The CWA set the groundwork for BMPs (Arthur et al. 1998, Speir 2001). One goal set by the CWA is to develop programs to control non-point source pollution. Best management practices for forestry pertaining to water quality stem from Section 208 and Section 319 of the CWA. Section 208 mandates that non-point sources such as silviculture should be monitored and appropriate plans to control such sources should be made. Section 319 of the Act modifies Section 208 and specifically addresses non-point sources and places implementation responsibility on states (Speir 2001).

Under Section 319, Governors of each state are required to submit a report to the EPA, which accomplishes the following:

- “1) ‘identifies those navigable waters within the State which, without additional action to control non-point sources of pollution, cannot reasonably be expected to attain or maintain applicable water quality standards,’
- 2) ‘identifies those categories and subcategories of non-point sources...which add significant pollution’ to those sub-par waters,
- 3) ‘describes the process...for identifying best management practices’ to control those problematic sources, and
- 4) ‘identifies and describes State and local programs for controlling’ non-point pollution sources” (Speir 2001).

In addition a management plan must be developed and proposed for implementation and must include:

- 1) “An identification of the best management practices and measures which will be undertaken to reduce pollutant loading resulting from each category, subcategory, or particular nonpoint source designated under paragraph (1)(B)...”
- 2) “An identification of programs .... to achieve implementation of the best management practices....”
- 3) “A schedule containing annual milestones for (i) utilization of the program implementation..., and (ii) implementation of the best management practices.....”
- 4) “A certification of the attorney general of the State or States... that the laws of the State or States, as the case may be, provide adequate authority to implement such management program..... “
- 5) “Sources of Federal and other assistance and funding....”

(33 U.S.C.A § 1329(b)(2))

States are required, “to the maximum extent practicable”, to utilize local and private experts on controlling non-point sources and to develop and implement management programs on a watershed-by-watershed basis (33 U.S.C.A § 1329(b)(4)).

Section 319 also addresses federal funding for implementation of programs to control non-point pollution (33 U.S.C.A § 1329(h)). If a state fails to submit a management plan to the EPA, then EPA is required to prepare the report and submit it to Congress. There is no penalty assessed to a state if they do not submit a plan. However,

federal grant money under Section 319 may not be available if a state does not submit a management plan (33 U.S.C.A § 1329(d)(3)).

In addition to federal water quality laws, states have water pollution laws of their own. Silviculture activities are generally covered under sections of other laws that deal with water quality. For instance, pesticide laws, estuary protection laws, and coastal zone protection laws of many states may affect silviculture. Under most of these laws pollution of a state's waters is prohibited unless a permit has been issued. Generally silviculture would be subject to the provisions of such water quality laws, but many states exempt such activities from permitting requirements. Prohibition against silviculture usually only occurs when pollution from activities is caused due to "negligence". In many cases implementation of best management practices (BMPs) provides legal protection for a silviculture operator and shows that a sincere attempt is being made to prevent the degradation of water quality by forestry activities. However, use of BMPs does not necessarily protect against private lawsuits made by citizens who can prove they have been adversely affected by forestry practices (Speir 2001).

### **III. Development of Forestry Best Management Practices**

When southern states first began developing ways to minimize non-point pollution (NPS) from silviculture the issue of whether to use a regulatory or non-regulatory approach was debated. Southern states and the EPA originally proposed a regulatory approach to enforce non-point pollution rules for silviculture. After consideration and consultation with the forestry community, both parties agreed to allow non-regulatory implementation. Their hopes were that by giving forest landowners and

forest practitioners the proper tools and guidance, non-point pollution from silviculture activities could be reduced (BMP Monitoring Task Force 1997).

Three main components the southern states and EPA deemed necessary for a successful non-regulatory approach were:

- “(1) Identification of best management practices (BMPs) to protect water quality during forestry operations; and
- (2) Widespread education/training of forestry practitioners and forest landowners to facilitate the implementation of BMPs; and
- (3) Routine monitoring of forestry operations to determine the level of BMP implementation” (BMP Monitoring Task Force 1997).

Although states are not required to use a regulatory approach towards minimizing non-point pollution from silvicultural activities, some do. The National Council of the Paper Industry for Air and Stream Improvement, Inc. (NCASI) submitted a report titled “Southern Regional Review of State Non-point Source Control Programs and Best Management Practices for Forest Management Operations”. This report describes the silviculture non-point pollution control program for each southern state. Table 1 below outlines the main agency from each state responsible for controlling NPS pollution from forestry activities and briefly describes the approach taken.



<b>Table 1. Enforcement of Forestry BMPs</b>		
<b>State</b>	<b>Main Agency Responsible for Controlling NPS Pollution from Normal Forestry Activities</b>	<b>Description of Silvicultural NPS Control Program</b>
Alabama	Alabama Forestry Commission	Non-regulatory; backed up by a limited regulatory program for violators; authority to make entire program regulatory if current voluntary approaches not effective.
Arkansas	Arkansas Forestry Commission	Non-regulatory; backed up by authority (which is not currently invoked) for a limited regulatory program for violators; authority to make entire program regulatory if current voluntary approaches not effective.
Florida	Florida Department of Forestry	Quasi-regulatory; non-regulatory with a regulatory backstop; authority to make entire program regulatory if current approaches not effective.
Georgia	Georgia Forestry Commission	Non-regulatory; regulatory in select sensitive areas; regulatory backstop for violators; authority to make entire program regulatory if current approaches not effective.
Kentucky	Kentucky Division of Forestry	Regulatory; commercial logging operation must have a certified master logger present.
Louisiana	Louisiana Department of Agriculture and Forestry, Office of Forestry	Non-regulatory; backed up by authority (not currently invoked) for a limited regulatory program for violators; authority to make entire program regulatory if current voluntary approaches not effective.
Mississippi	Mississippi Forestry Commission	Non-regulatory; backed up by authority (not currently invoked) for a limited regulatory program for violators; authority to make entire program regulatory if current voluntary approaches not effective.
North Carolina	North Carolina Division of Forest Resources	Regulatory; Forestry Practice Guidelines (FPGs), implemented by voluntary BMPs; authority to make regulations even more stringent if current approaches not effective.
Oklahoma	Oklahoma Department of Agriculture, Forestry Services	Non-regulatory; backed up by authority (not currently invoked, may be in future) for a limited regulatory program for violators, and the authority to make entire program regulatory if current voluntary approaches not effective.
South Carolina	South Carolina Forestry Commission	Non-regulatory; backed up by a limited regulatory program for violators; authority to make entire program regulatory if current voluntary approaches not effective.
Tennessee	Tennessee Department of Agriculture, Division of Forestry	Strictly voluntary, non-regulatory; regulatory or enforcement actions taken only if NPS pollution results from point source discharge directly into a

		waterbody.
Texas	Texas Forest Service	Non-regulatory; backed up by authority (not currently invoked) for a limited regulatory program for violators; authority to make the entire program regulatory if current voluntary approaches are not effective.
Virginia	Virginia Department of Forestry	Non-regulatory; backed up by an aggressive regulatory program for violators managed by VDOF, by authority (not currently employed) for an additional regulatory element for violators on the part of VWCB and by authority to make entire program regulatory if current voluntary approaches not effective.

Source: (1) National Council of the Paper Industry for Air and Stream Improvement, Inc. (NCASI). 1994. *Southern Regional Review of State Nonpoint Source Control Programs and Best Management Practices for Forest Management Operations*. Technical Bulletin No. 686. New York, NY.

(2) Prud'homme, Bruce A. and John G. Greis. 2001. Southern Forest Resource Assessment Draft Report: Aqua-4: Best Management Practices in the South. Region 4, US Environmental Protection Agency and Southern Region, USDA Forest Service. [www.srs.fs.fed.us/sustain](http://www.srs.fs.fed.us/sustain)

Forestry best management practices are categorized by forestry practice. A state usually chooses which practices to include based on how to best allow forestry activities and timber harvesting to exist without degrading water quality or aquatic habitats and organisms (Stringer and Thompson 2000). Potential pollutants resulting from forestry activities such as sediment, chemicals, harvest debris, equipment fluids, and thermal pollution are considered when forming BMPs (Arthur et al. 1998, Stringer and Thompson 2000). Also, a state's topography, types of water bodies, soils, and forestry activities can influence the development of guidelines. The amount of scientific information available on forestry sites as well as the state's societal and political stance are other factors that are considered when creating BMPs (Stringer and Thompson 2000).

Different types of information may be given in a state's BMP guidelines. States may provide BMP guidelines that are either explanatory or prescriptive (Stringer and

Thompson 2000). One example of an explanatory guideline would be “Leave enough trees to prevent increases in water temperatures” (Arkansas Forestry Commission). A prescriptive BMP usually provides a specific numeric guideline. One prescriptive example pertaining to the amount of canopy cover that should be left in a streamside management zones is “75 percent pre-harvest shade” (North Carolina Division of Forest Resources 1989). Whether or not a BMP guideline is explanatory or prescriptive depends on the forestry practice. Some practices, such as chemical application for site preparation, may not require specific quantitative guidelines due to the variation in chemical amounts and concentrations needed for different applications.

Practices commonly covered in state BMP manuals are: Streamside Management Zones (SMZs), Forest Roads, Stream Crossings, Timber Harvesting, and Site Preparation/Reforestation. Some states include other categories or use different terminology to describe practices. For this paper the aforementioned categories will be compared between the 13 southern states.

### ***Streamside Management Zones***

Streamside management zones (SMZs) are the “strips of land immediately adjacent to a water of the state where soils, organic matter and vegetation are managed to protect the physical, chemical, and biological integrity of surface water adjacent to and downstream from forestry operations” (Alabama Forestry Commission 1993). Definitions of SMZs by other states may differ slightly, but the land area being described remains consistent. Guidelines given for SMZs generally focus on minimizing the amount of exposed ground adjacent to streams or other water bodies and retaining trees and vegetation next to streams to regulate water temperature. Inclusion of the word

‘management’ by most states implies that some forestry activity is allowed within these areas (Stringer and Thompson 2000).

The trees and vegetation found within SMZs help to slow and spread out surface water flow, provide habitat and travel passageways for wildlife, trap and filter out sediment, provide shade to streams for temperature regulation, and act as a buffer for chemicals such as pesticides and fertilizers (Georgia Forestry Commission). Depending on the state, SMZs are also referred to by other names such as Special Management Zones (Florida), Riparian Management Zones (Indiana) or simply “buffer strips” (Stringer and Thompson 2000). Although most states restrict certain activities within these areas some forestry operations are allowed.

How an SMZ is designated depends on the state. Since the grade of the land greatly influences erosion and sedimentation, states generally determine necessary SMZ width based on the slope of the surrounding land. States usually designate different specifications for SMZs depending on the type of waterbody. Stream types are important because of the differences in the amount of time water actually flows within the water body and whether or not they support aquatic organisms (Stringer and Thompson 2000). Most states only recognize streams whereas some recognize domestic water supplies, ponds, and wetlands (Blinn and Kilgore 2001). All 13 southern states have guidelines for perennial and intermittent streams. Guidelines for other stream types and water bodies such as ephemeral channels, cold-water aquatic habitats, and those found in forested wetlands are not included in every southern state’s BMP manual.

## Perennial Streams

A perennial stream can be defined as “a stream containing water for a majority of the year flowing in a well-defined channel” (North Carolina Division of Forest Resources 1989). For most southern states prescriptive guidelines for perennial streams are given for the amount of canopy cover and SMZ width. The amount of canopy cover left next to a water body is important for thermal regulation. Recommended SMZ width for perennial streams vary from state to state in the south. A range of recommended SMZ width is usually given by each state. Louisiana does not provide specific width parameters stating that SMZ width is “site specific” and dependent on several factors (Louisiana Department of Agriculture and Forestry). Table 2 shows the SMZ width and canopy cover guidelines for perennial streams in southern states.

<b>Table 2. SMZ Specifications for Regular Perennial Waters</b>		
<b>States</b>	<b>Canopy Cover (% Retained)</b>	<b>SMZ Width in Feet (Slope dependent)</b>
Alabama	50 (or 70 ft <sup>2</sup> /ba/a)	35 (Widen depending on slope and erodibility)
Arkansas	Minimum of 50ft <sup>2</sup> ba/a. Leave all trees if less than 50 ft <sup>2</sup> ba/a exists.	35-80 (applicable to all non-ephemeral streams)
Florida (Special Management Zone)	50% of fully stocked stand.	35-200 (Depending on type and size of water) No loading decks or landings allowed within SMZ.
Georgia	50 (or 50 ft <sup>2</sup> ba/a)	40-100
Kentucky	50	25-165 (for disturbed ground) 25 or 55 (for overstory cover)
Louisiana	Leave enough trees to maintain normal water and shade conditions.	50 (streams less than 20 feet wide) 100 (streams greater than 20 feet wide) Site specific based on soil type, slope, vegetative cover, stream character and worst-case storm flows.
Mississippi	50	30-290 (Dependent on slope and erodibility of soil)
North Carolina	75% preharvest shade	50

Oklahoma	Not addressed	50
South Carolina	50 ft <sup>2</sup> ba/a	40-120
Tennessee	50	24-145
Texas	50 (or 50 ft <sup>2</sup> ba/a)	50 (adjust for slope, soil type and cover type) 100 for municipal water supplies
Virginia	50	50 (not slope dependent)

- Source: (1) Arkansas Forestry Commission. 2002. *Arkansas forestry best management practices for water quality protection*. Little Rock, AR.
- (2) Stringer, Jeff and Amy Thompson. *Comparison of Forestry Best Management Practices Part I: Streamside Management Zones*. May/June 2000. Forest Landowner.

### Intermittent Streams

Intermittent streams are generally defined as “streams that flow only during wet periods of the year and flow in a continuous, well-defined channel” (North Carolina Division of Forest Resources 1989). Like perennial streams, SMZ widths for intermittent streams are usually measured based on the slope of the land. BMP guidelines for intermittent streams are sometimes less stringent than those for perennial streams. For example, Alabama and Tennessee require 50% canopy cover retained in SMZs for perennial streams and 0% overstory cover for intermittent streams (Alabama Forestry Commission 1993, Tennessee Department of Agriculture, Forestry Division). Due to the lack of constant water flow, intermittent streams may not harbor aquatic organisms and therefore less stringent canopy cover guidelines are accepted. In addition, intermittent streams occur much more frequently in forestland than perennial streams. Extremely restrictive guidelines could greatly affect the profitability of harvest (Stringer and Thompson 2000). Table 3 shows the SMZ guidelines available for intermittent streams.

<b>Table 3. SMZ Specifications for Intermittent Waters.</b>			
<b>States</b>	<b>Overstory Cover (% Retained)</b>	<b>SMZ Width in Feet (Slope dependent)</b>	<b>Additional Comments</b>
Alabama	0	35 (Widen depending on slope and erodibility)	Leave vegetation and organic debris to protect forest floor during regeneration.
Arkansas	Leave enough trees to prevent increases in water temperatures.	Site specific depending on soil, slope, vegetation, flow and stream classification.	
Florida	Leave stringer (a narrow band of streambank trees).	35-300 (depending on site sensitivity class)	
Georgia	25% canopy cover (or 25 ft <sup>2</sup> ba/a)	20-50	
Kentucky	0	25-65	Do not block drainage w/tops.
Louisiana	N/A	35	SMZ width site specific based on soil type, slope, vegetative cover, stream character and worst-case storm flows.
Mississippi	N/A	30	SMZ width site specific and should be increased under certain conditions.
North Carolina	75% preharvest shade	50	
Oklahoma	Not addressed	50	
South Carolina	Leave understory vegetation and organic debris to protect forest floor and stream banks.	40-120	
Tennessee	0	25	Minimize soil exposure
Texas	50 (or 50 ft <sup>2</sup> ba/a)	50	Remove debris.
Virginia	50	25	

Source: Stringer, Jeff and Amy Thompson. *Comparison of Forestry Best Management Practices Part I: Streamside Management Zones*. May/June 2000. Forest Landowner.

### Special Waters

Some states designate guidelines for special waters. Special waters may include cold-water aquatic habitats, forested wetlands, and underground streams (Stringer and Thompson 2000). Specifically, cold-water aquatic habitats may include trout streams. According to Georgia's BMP manual, trout require high-quality water at temperatures

less than 70°F. In addition, insects important to trout survival are sensitive to high temperatures and sedimentation (Georgia Forestry Commission 1999). As shown in Table 4 only a few southern states designate guidelines for Cold-Water Aquatic Habitats.

Some states dedicate separate BMP manuals for water bodies within forested wetlands while others include sections in their regular BMP manual. Since forested wetlands are environmentally sensitive some BMP guidelines included for wetlands may be more stringent than those for normal forestry sites. Guidelines for forested wetland are shown in Table 5 (Stringer and Thompson 2000).

<b>Table 4. SMZ Guidelines for Cold-Water Aquatic Habitats.</b>			
<b>States</b>	<b>Minimum Width No Cut (ft)</b>	<b>Overstory Cover (% Retained)</b>	<b>SMZ Width (ft) Slope dependent</b>
Georgia	25 (within primary or secondary trout streams)	50 ft <sup>2</sup> ba/a	100 Additional option is available if you consult with a qualified professional.
Kentucky	0	75 (for 60 ft)	25-165
North Carolina	0	75 preharvest shade	50-125
South Carolina	0	50 ft <sup>2</sup> ba/a	40-120
Virginia	0	50	60-120

Source: Stringer, Jeff and Amy Thompson. *Comparison of Forestry Best Management Practices Part I: Streamside Management Zones*. May/June 2000. Forest Landowner.



<b>State</b>	<b>Overstory Cover (% Retained)</b>	<b>SMZ Width in Feet (Slope dependent)</b>
Alabama	50	35 (widen depending on slope and erodibility)
Florida	N/A	Apply appropriate SMZ for site.
Georgia	N/A	Apply appropriate SMZ to any stream channel.
Kentucky	50	50
Tennessee	50	50
Texas (For perennial streams in wetlands)	50% or 50 ft <sup>2</sup> ba/a	50
Virginia	50% around seeps	50-150 (around seeps)

Source: Stringer, Jeff and Amy Thompson. *Comparison of Forestry Best Management Practices Part I: Streamside Management Zones*. May/June 2000. Forest Landowner.

### Ephemeral streams or channels

Ephemeral streams or channels are defined as “drainage channels where surface water occurs only after rain or snow melt, and do not continuously flow during wet seasons” (Stringer and Thompson 2000). The guidelines for these water bodies are usually descriptive and most states that recognize ephemeral streams in their BMP manuals do not give width values. Since ephemeral channels do not flow continuously their potential for containing aquatic life is poor. Therefore, most states do not provide recommendations for harvest next to ephemeral channels. However, some states recognize that ephemeral channels may run into intermittent or perennial streams and recommend using guidelines for those stream types when this situation occurs. Table 6 below gives the guidelines available for ephemeral channels for southern states.

<b>Table 6. Guidelines for Ephemeral Channels.</b>			
<b>State</b>	<b>Overstory Cover (% Retained)</b>	<b>Distance of Protective Area in Feet (Slope dependent)</b>	<b>Additional Comments</b>
Arkansas	Leave enough trees to prevent increases in water temperatures	Site specific depending on soil, slope, vegetation, flow and stream classification.	
Georgia			Avoid soil disturbance. Treat confluence with intermittent or perennials treat as intermittents.
Kentucky			Do not leave concentrated debris or fill.
North Carolina			Minimal soil disturbance at confluence with intermittents or perennials.
South Carolina			Avoid soil disturbance and use or storage of hazardous fluids.
Virginia			Avoid soil disturbance

Source: Stringer, Jeff and Amy Thompson. *Comparison of Forestry Best Management Practices Part I: Streamside Management Zones*. May/June 2000. Forest Landowner.

### ***Forest Roads***

Forest roads may include access or haul roads, skid trails, and other features such as water control structures and cross-drain structures pertaining to roads on a forest site. All southern states set guidelines for forest roads, but which aspects of road building and use they include vary. Some practices such as the use of skid trails may be covered under other sections of a state's BMP manual, such as harvesting.

Setting guidelines for forest roads is important because they can be a significant source of water pollution, namely sedimentation. Guidelines differ from state to state depending on topography, soils or even the forestry techniques used. The number and density of roads on a forest site and how long the roads have been in use are important.

In addition, how the roads were constructed and how close to streams and channels the roads are located can affect how much erosion occurs. Most southern states do not have explicit guidelines for road and skid trail density or intensity of use (Stringer and Thompson 2001).

Forest roads are commonly referred to as haul roads or access roads depending on whether they are used for timber harvesting activities. These roads may be permanent or temporary. Grade of forest roads is included in most BMP guidelines. Most southern states specify the maximum grade a road can be constructed (Stringer and Thompson 2001). Those states that do not specify grade with values usually provide statements such as “minimize where soils are highly erodible and/or topography is steep” (Alabama Forestry Commission 1993).

Grade of a road is measured by slope, which is the rise or fall over the length of the road (every 100 feet horizontally). Susceptibility to erosion is dependent on grade. The steeper the grade of a road the more likely erosion will occur (Stringer and Thompson 2001).

In addition to recommendations for grade, all southern states have BMP specifications for water control structures and cross-drain structures. Water control structures include turnouts, crowning, and outsloping. These structures help to continuously move water off of the road surface in order to reduce erosion (Stringer and Thompson 2001). Cross-drain structures include culverts, and reverse grade structures such as broad-based dips or rolling dips. Cross-drain structures are used on various points on a road to move water off the road (Stringer and Thompson 2001).

Two of the more widely used and specified reverse grade structures are broad-based dips and rolling dips. A broad-based dip is a technique “used to form a reverse slope in a road surface with an outsloped cross drain” (North Carolina Division of Forest Resources 1989). This technique is used for drainage of haul roads with moderate slope, and is not for use on steep roads or skid trails. A rolling dip is “a rounded hump and reverse slope in a skid trail surface with an outsloping low point for natural cross drainage” (North Carolina Division of Forest Resources 1989). This technique can be used on steep slopes and skid trails. Neither of these techniques should be used for draining streams or seeps (North Carolina Division of Forest Resources 1989). Table 6 shows grade, broad-based dip and rolling dip specifications for southern states.

State	Grade	Rolling Dips		Broad-based Dips	
		Grade	Spacing	Grade	Spacing
Alabama	Minimize where soils are highly erodible and/or topography is steep.	N/A	N/A	3-15%	235'-125'
Arkansas	<10%, or >10% <500', or >15% <200' (Highly erodible soils: <8%; can exceed 8% for 150' if appropriate BMPs are implemented)	10-15% 15%+	135' 120'	2-10%	300-140'
Florida	No recommendation	N/A	N/A	3-23% (site)	180-110'
Georgia	<10% or 12% for short distances	3-12% Temp. Roads	235-135'	3-12% Perm. Roads	235-135'
Kentucky	<15% or 18% for <200'	2-18%	500-100'	2-10%	500-200'
Louisiana	<10%, or >10% <500', or >15% <200' (highly erodible soils <8%, or >12% for 150' (prevent erosion))	2-15%	300-127'	2-8%	300-150'
Mississippi	<10%, or if >10% for short distances	N/A	N/A	Formula: 400'/Slope% + 100'	
North Carolina	<10% or >10% for less than 200' (highly erodible soils <8%)	N/A	N/A	1-10%	500-140'
Oklahoma	<10% or 18% for <500'	N/A	N/A	2-10%	300-140'
South Carolina	<10%	N/A	N/A	2-25%	300-115'

Tennessee	<10%	N/A	N/A	2-10%	300-140'
Texas	<10% or >10% for <500', or >15% for <200'	2-15%+	180-120'	1-12%	500-130'
Virginia	<10%, or 15% for <200'	2-15%+	180-120'	2-12%	300-135'

Source: (1) Arkansas Forestry Commission. 2002. *Arkansas forestry best management practices for water quality protection*. Little Rock, AR.

(2) Stringer, Jeff and Amy Thompson. *Comparison of Forestry Best Management Practices. Part II: Forest Roads and Skid Trails*. Forest Landowner. March/April 2001.

### Skid Trails

A skid trail is an “unsurfaced, single lane path or narrow road that may be steeper and more narrow than a truck haul road. Skid trails serve as transport routes for equipment conveying trees, logs or other material from the place of felling to a concentration point, where they are stored or loaded for further transport” (North Carolina Division of Forest Resources 1989). Since skid trails can be significant sources of erosion, all southern states have included BMP specifications for grade.

The recommendations given for grade of skid trails by southern states vary considerably. The differences in topography and equipment use among states makes it difficult to have the same recommendations for skid trails. Sometimes harvest operations must construct skid trails in areas of steep slope in order to avoid damaging other more vulnerable areas. In addition, construction of reverse grade structures to limit water flow over skid trails is not possible during harvesting operations. Damage most likely would occur to the structures during the skidding process and diminish their effectiveness.

Therefore, states provide guidelines for retiring skid trails, which includes construction of reverse grade structures such as water bars (Stringer and Thompson 2001).

Water bars are water control structures often put in place on skid trails or roads after forest harvesting activities have been completed. Water bars as defined by the North Carolina Division of Forest Resources are “a combination “mound-trench” built into the trail, road or fire break and placed on a downslope angle across the travelway” (North Carolina Division of Forest Resources 1989). Water bars intercept and divert surface water off the road or trail and minimize excessive erosion and/or gullyng. Water bars can provide conditions suitable for natural or artificial vegetative cover” (North Carolina Division of Forest Resources 1989). Table 7 contains skid trail and water bar BMP specifications for southern states.

<b>Table 7. Skid Trail BMP Specifications</b>			
<b>State</b>	<b>Grade</b>	<b>Spacing of Water Bar</b>	
		<b>Grade</b>	<b>Spacing Distance</b>
Alabama	N/A	3-40%	200-30'
Arkansas	N/A	2-30%	250-35'
Florida	N/A	0-23% based on site	250-30'
Georgia	<40% except for short stretches	2-40%	250-30'
Kentucky	Minimize where possible	1-40%	400-29'
Louisiana	N/A	2-11%	250-60'
Mississippi	<15%	2-40%	250-30'
North Carolina	<25%	5-30% water bars 5-16% rolling dips	135-35' 150-120"
Oklahoma	N/A	2-40%	250-30'
South Carolina	N/A	2-25%	245-40'
Tennessee	<10%, or short distances <30%	2-10%	300-140'
Texas	<15%	2-30%	250-35'
Virginia	<15%	2-30%	250-35'

Sources: Stringer, Jeff and Amy Thompson. *Comparison of Forestry Best Management Practices. Part II: Forest Roads and Skid Trails*. Forest Landowner. March/April 2001.

### ***Stream Crossings***

Stream crossings consist of different methods for crossing streams or channels on a forested site. The most common methods included by many of the southern states

include culverts, bridges, and fords. Some states include other methods or use different terminology in describing stream crossings.

Many states discourage the use of stream crossings if possible, citing them as possible sources for sedimentation and negative impacts to streams and other waterbodies. However, most forest sites have streams or other water bodies and construction of crossings is usually necessary. Some states consider stream crossings the most significant feature of a road system because of the potential for negative stream impact (Georgia Forestry Commission 1999).

Most southern states provide general stream crossing guidelines and give specific information for constructing the actual stream crossing mechanism. Guidelines for building stream crossings may include detailed instructions and/or diagrams. In addition, some southern states such as North Carolina give guidelines for inspection of stream crossings in order to insure safe and proper working conditions. Several of the more common BMPs for stream crossings include: cross streams at right angles, approach streams at gentle angles, locate crossings where stream channels are straight, and remove temporary stream crossings when operations are complete (Mississippi Forestry Commission 2000; Tennessee Department of Agriculture, Division of Forestry; Louisiana Department of Agriculture and Forestry).

### Culverts

Culverts, or closed culverts, are pipe which can be laid in a stream bottom and allow for the continued flow of water while providing a base for stream crossing. All 13 southern states list culverts as a possible method of stream crossing. Specifications for installing culverts and choosing the correct pipe diameter are given by some southern

states. Pipe diameter specifications may pertain to all topographic areas within the state, as in North Carolina, or may contain different diameters depending on the region within the state, as given in Florida's BMP guidelines (North Carolina Division of Forest Resources 1989; Florida Department of Agriculture and Consumer Services).

### Bridges

Bridges are another type of stream crossing with recommendations provided for in most southern state BMP guidelines. Most southern states recognize bridges as being the least disruptive stream crossing method in terms of altering stream flow (Alabama Forestry Commission 1993). Bridges may be permanent or temporary and can be made out of different types of materials (Stringer and Perkins 1997). Many states prefer the use of temporary bridges that can be removed after site activity has ceased.

### Fords

"Fords are 'Minimum use' crossings where the stream system has an existing or applied firm base"(North Carolina Division of Forest Resources 1989). Many states recommend only installing fords when other stream crossing alternatives are infeasible (Alabama Forestry Commission 1993; Stringer and Perkins 1997; Louisiana Department of Agriculture and Forestry). However, several southern state BMP manuals recommend using fords if installation of culverts or bridges will increase soil erosion more than fords (Mississippi Forestry Commission 2000). Generally states require fords to be used only as haul roads and not as skid trails (Georgia Forestry Commission 1999). Table 8 contains general guidelines for use of culverts, bridges, and fords.



**Table 8. BMP Guidelines for Stream Crossings**

State	Culverts	Bridges	Fords
Alabama	<p>-Properly sized and installed culverts should be used to reduce road washouts and impoundments of water.</p> <p>-One large pipe is better than several smaller pipes.</p> <p>-Culverts should be long enough to extend at least one foot beyond the fill on either end.</p> <p>-Fill material should be stabilized using rip rap, hay bales, mulch, sand bags, vegetation, or concrete.</p> <p>-Culverts should be cleaned out regularly.</p> <p>-After operation completed, temporary crossings should be removed and site stabilized; stabilize and maintain all permanent crossings.</p>	<p>-Banks and fill material must be stabilized and protected from erosion.</p> <p>-Spans must be installed to permit passage of all expected high flow.</p>	<p>-Can be used when streambed is firm, banks are low and the stream is shallow.</p>
Arkansas	<p>-Pipe culvert should be of the proper type, size, and material to handle maximum stream flow.</p> <p>-Pipe lengths should extend at least one foot beyond the edge of the fill material.</p> <p>-Place the culvert on a 1-2% downgrade to prevent clogging.</p> <p>-Install erosion protection measures.</p>	<p>-Construct bridges with minimum disturbance to the stream bank, stream channel, and SMZ.</p> <p>-Provide adequate erosion protection.</p> <p>-Use temporary bridges to minimize stream bank disturbances.</p>	<p>-Use rock fords if no practical alternative exists.</p> <p>-Approaches, stream banks, and stream bottoms must be hard enough to minimize stream bottom and bank disturbance.</p>
Florida	<p>-BMP guidelines include culvert diameters based on stream width (ft.) and stream depth (ft.).</p> <p>-Several tables for culvert diameters are given dependent on the slope of the surrounding land.</p> <p>-General culvert guidelines include:</p> <ul style="list-style-type: none"> <li>• Place culvert in section of stream that is relatively straight.</li> <li>• Place bottom of culvert at same elevation as bottom of stream and at approximately the same slope.</li> <li>• Keep height of entire structure (culvert plus fill) as low as possible to reduce the potential for impounding large areas of water.</li> <li>• Use culvert diameter that is sufficient to carry normal flow expected.</li> <li>• When crossing broad channels or wetlands, several small culverts, spaced throughout the crossing, is normally preferable to a single large culvert.</li> <li>• For temporary stream crossings, a culvert may be sized to reflect seasonal flow conditions.</li> <li>• Periodically inspect all culverts to prevent clogging, plugging, and eventual failure.</li> </ul>	<p>N/A</p>	<p>-(Referred to as hard surface crossings).</p> <p>-Use clean material that will not rapidly degrade and that is heavy enough to stay in place during high flow conditions.</p> <p>-Do not use asphalt or other petroleum-based materials.</p> <p>-Do not construct such crossings where bottom is mucky, muddy or otherwise unstable.</p> <p>-Do not use logs or logging slash as permanent hard surface crossing material. Logs may be used for temporary crossings if removed at end of operation.</p> <p>-Keep height of surfacing material to a minimum.</p>

<p>Georgia</p>	<ul style="list-style-type: none"> <li>-Where fords not available or recommended, culverts can be used.</li> <li>-Consult a qualified professional when crossing streams with a watershed larger than 300 acres.</li> <li>-Size permanent culverts so that the cross-sectional area will accommodate expected 25-year, 24-hour storm flows.</li> <li>-Size temporary culverts so that the cross sectional area will accommodate the 2-year, 24-hour storm flows.</li> <li>-Under normal conditions two alternative methods of culverting can be used:             <ol style="list-style-type: none"> <li>(1) Smaller multiple culverts can be substituted to provide for the same cross-sectional area of pipe required as shown in the above table.</li> <li>(2) Combination of a smaller culvert(s) with rock surfaced road dips constructed in the roadbed to handle the runaround flow from larger storm events.</li> </ol> </li> <li>-Culverts less than 15 inches in diameter are not recommended.</li> <li>-Place culvert in straight section of stream.</li> <li>-Place bottom of culvert at same elevation as the bottom of stream.</li> <li>-Periodically inspect culverts and remove any debris inside.</li> <li>-Remove all temporary culverts and fill material used in stream or wetland crossings and stabilize streambanks when operations are completed.</li> </ul>	<ul style="list-style-type: none"> <li>-Use bridges on watersheds of 300 acres or more if other alternatives are not suitable for containing storm flows.</li> <li>-Remove temporary bridges and stabilize approaches and stream banks when operations are completed.</li> </ul>	<ul style="list-style-type: none"> <li>-Only use fords for haul roads. (Not skid trails)</li> <li>-Where necessary, establish a smooth, hard-surface, low water crossing.</li> <li>-Permanent fords use gravel or rock filled Geoweb<sup>®</sup> or concrete pads.</li> <li>-Temporary fords use dragline mats or logs to protect stream bottom.</li> <li>-Material should not significantly impound stream flow, impede fish passage or cause erosive currents.</li> </ul>
<p>Kentucky</p>	<ul style="list-style-type: none"> <li>-Culvert inlets should be placed level with the drainage and as near as possible to the natural channel.</li> <li>-Adequate cover is needed over the culvert; a minimum of one foot or half the culvert diameter, whichever is greater.</li> <li>-If adequate cover not achievable, use an arch pipe or install two smaller culverts.</li> <li>-Inspect culvert regularly for obstructions.</li> <li>-Check for erosion of bank near inlet and erosion of fill.</li> </ul>	<ul style="list-style-type: none"> <li>-Check approaches and structure for wear.</li> <li>-Armor or riprap loose fill along stream banks where appropriate.</li> </ul>	<ul style="list-style-type: none"> <li>-On permanent-use roads, fords should be graveled on each side where significant soil disturbance may occur.</li> <li>-Road should have reverse grade structure or other water diversion to prevent water from running down road into stream during high flows.</li> <li>-Stabilize fill areas and disturbed banks in vicinity of stream crossings.</li> </ul>
<p>Louisiana</p>	<ul style="list-style-type: none"> <li>-Culverts should be angled 30-45 degrees to direction of water flow.</li> <li>-Erosion protection should be provided for outflows of culverts.</li> <li>-Erosion protection can be in form of headwalls, riprap, geotextile filter cloth, large stone, or prefabricated outflow and inflow devices.</li> </ul>	<ul style="list-style-type: none"> <li>-Should be constructed with minimum disturbance to the stream bank, channel, and adjacent SMZ.</li> <li>-When necessary to protect approaches and roadbed fills near bridges, erosion protection should be provided by riprap, head walls, wing walls, etc.</li> <li>-Use of temporary bridges may be necessary to</li> </ul>	<ul style="list-style-type: none"> <li>-Rock fords may be used when no other practical alternative exists.</li> <li>-Approaches, stream banks, and stream bottoms must be hard enough or sufficiently stabilized to minimize stream bottom and bank disturbance.</li> <li>-Crossing streams at fords should take place when stream flow is down and the threat of sedimentation is low.</li> </ul>

		minimize stream bank disturbances.	
Mississippi	<ul style="list-style-type: none"> <li>-If temporary culverts in use for more than ten days, fill material should be stabilized using seed and mulch.</li> <li>-Whenever possible, use logs or stems as fill over temporary culverts instead of fill dirt.</li> <li>-Stabilize approaches during and after construction.</li> <li>-Remove all temporary fill material and restore channel to original elevation when logging is complete.</li> <li>-Keep culverts clear of debris to allow unrestricted flow.</li> <li>-All culverts should be installed at the proper level and of sufficient size to carry anticipated water flow.</li> <li>-At road crossings of permanent streams, all structures should be placed to allow fish passage.</li> <li>-When using combinations of culverts to carry equivalent water flow use culverts that are <math>\frac{3}{4}</math> the diameter of the recommended diameter.</li> <li>-Hollow log culverts only acceptable on temporary roads if removed when road is retired.</li> </ul>	<ul style="list-style-type: none"> <li>-Bridges should be used over larger streams where heavy or long-term traffic is expected.</li> <li>-Does not include recommendations for bridge construction.</li> </ul>	<ul style="list-style-type: none"> <li>-Use fords only if streambeds are solid and if the installation of bridges and culverts will accelerate soil movement.</li> <li>-Enforce both approaches with gravel.</li> <li>-Do not use fords in sensitive water areas.</li> </ul>
North Carolina	<ul style="list-style-type: none"> <li>-Install culverts of adequate type, proper size and length.</li> <li>-Inlet and outlet ends must extend beyond the toe of side fill slopes.</li> <li>-Select installation sites where stream is straight and bank conditions are favorable.</li> <li>-For permanent culverts, best to install one large culvert than several smaller diameter culverts.</li> <li>-Place culvert on the natural stream bottom.</li> <li>-Culvert must have 2-4% grade, downstream, to aid in self-cleaning.</li> <li>-On-site material, free of debris may be used as backfill.</li> </ul>	<ul style="list-style-type: none"> <li>-Use bridges on streams that drain to large watersheds where culverts will not handle flow.</li> <li>-Select proper type, size, and material to handle the maximum stream flow.</li> <li>-Protect stream channel and stream banks from erosion during site clearing and bridge construction.</li> <li>-Provide abutments and headwalls where necessary to help handle high-flow conditions and stabilize crossing area.</li> <li>-Stabilize road surfaces and cut and fill slopes as soon as practical.</li> </ul>	<ul style="list-style-type: none"> <li>-Apply adequate riprap stone, a layer of poles or other effective material to crossings to stabilize road or trail, banks and stream channel.</li> </ul>
Oklahoma	<ul style="list-style-type: none"> <li>-Use properly sized and installed culverts.</li> <li>-Do not obtain culvert fill material from within the stream channel.</li> <li>-Culverts should be open and clean to allow free passage of water.</li> </ul>	<ul style="list-style-type: none"> <li>-Bridges should not constrict clearly defined stream channels.</li> <li>-Permanent bridges should be designed to pass the normal flood level, or road approach should be constructed to provide erosion protection from overflow floodwaters that exceed the water carrying</li> </ul>	N/A

		<p>capacity.</p> <ul style="list-style-type: none"> <li>-Low-water bridge fills and earth embankments constructed for use as bridge approaches should be protected from erosion by high water.</li> <li>-Construct bridges so as to cause no more than minimal changes in natural streambeds during high water periods.</li> </ul>	
South Carolina	<ul style="list-style-type: none"> <li>-Ensure proper sizing and installation of culverts.</li> <li>-Stabilize disturbed soil around crossings soon after construction.</li> <li>-Temporary culverts are sized for storm flows with a two-year -recurrence interval.</li> <li>-Permanent culverts are sized for storm flows with 25-year-recurrence intervals.</li> <li>-Multiple smaller culverts designed to carry equivalent water flow can be substituted for culvert sizes provided in BMP manual.</li> </ul>	N/A	N/A
Tennessee	<ul style="list-style-type: none"> <li>-Use proper sized culvert and installation methods.</li> <li>-Follow culvert installation guidelines provided in forest roads section.</li> </ul>	<ul style="list-style-type: none"> <li>-Locate bridges at right angles to stream where approaches are level.</li> <li>-Construct bridge crossings where the stream channel is straight with an unobstructed flow of water.</li> <li>-Place bridge abutments in a direction parallel to the stream flow and imbedded in good foundation materials.</li> </ul>	<ul style="list-style-type: none"> <li>-Use fords when necessary, but such crossings should be made at right angles to streams, not interfere with stream flow and have a hard bottomed base.</li> </ul>
Texas	<ul style="list-style-type: none"> <li>-Pipe length should be long enough so that each end extends at least one foot beyond the edge of the fill material.</li> <li>-Pipe culverts should be of the proper type, size, and material to handle maximum stream flow.</li> <li>-Culvert should be placed on a 1% to 2% downgrade to prevent clogging, but laid as closely as possible to the natural grade of the drain.</li> <li>-Erosion protection measures can be installed at the culvert outlet to minimize downstream erosion. Measures may include rip rap, geotextile filter cloth, large stone, prefabricated outflow devices, velocity reducers, etc.</li> </ul>	<ul style="list-style-type: none"> <li>-Bridges should be constructed with minimum disturbance to the stream bank, channel, and adjacent SMZ.</li> <li>-When necessary, adequate erosion protection should be provided for approaches and roadbed fills near bridge. Use head walls, wing walls, rip rap, etc.</li> <li>-Use temporary bridges when possible to minimize stream bank disturbances.</li> </ul>	<ul style="list-style-type: none"> <li>-Rock fords may be used when no other practical alternative is available.</li> <li>-Approaches, stream banks, and stream bottoms must be hard enough or sufficiently stabilized to minimize stream bottom and bank disturbance.</li> </ul>
Virginia	<ul style="list-style-type: none"> <li>-Culverts can be temporary or permanently installed.</li> <li>-Culvert sizing may be dependent on whether permanent or temporary.</li> <li>-Crossings should be installed at right angles to</li> </ul>	<ul style="list-style-type: none"> <li>-Temporary bridges should be installed at right angles to the stream.</li> <li>-Approaches should be stabilized.</li> </ul>	<ul style="list-style-type: none"> <li>-Streambeds should have a firm natural rock base.</li> <li>-Dumping of unnatural or foreign material into stream to create ford is not</li> </ul>

	<p>streams.</p> <ul style="list-style-type: none"> <li>-Utilize erosion protection measures. Examples are rip-rap, filter cloth, seeding and mulching.</li> <li>-Periodically inspect culverts for possible maintenance needs.</li> <li>-See table in BMP manual for specific pipe diameters.</li> </ul>	<ul style="list-style-type: none"> <li>-Bridge approaches should be straight.</li> <li>-Remove temporary bridges when logging is complete.</li> </ul>	<p>permitted.</p> <ul style="list-style-type: none"> <li>-Use of wooden mats to increase the carrying capacity of the ford is permitted. Mats must be removed after use.</li> <li>-Ford should be temporary and restricted to low traffic volumes.</li> <li>-Water depth at ford should be less than two feet.</li> <li>-Locate where streambanks are low and approaches stable.</li> <li>-If necessary, stabilize approaches with rock a minimum of 50 feet from water's edge on both sides of stream.</li> <li>-Rock approaches should be underlined with geotextile fabric.</li> </ul>
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### *Timber Harvesting*

The harvest of trees on a forest site is an important activity in most forest management schemes. The process of harvesting trees on a forest site temporarily disturbs the forest environment. In order to minimize site disturbance most southern states encourage pre-planning for the harvest activity and adherence to BMP guidelines. The amount of detail provided in the BMP guidelines by southern states for pre-planning for timber harvest varies. For example, Virginia's BMP guidelines recommend a preliminary pre-harvest plan as well as a comprehensive harvest plan. The preliminary pre-harvest plan is a simple plan prepared for a forest landowner by a Division of Forestry area forester, forestry consultant, or procurement forester. The pre-harvest plan is prepared before a timber sale is made. The comprehensive harvest plan is significantly more detailed than the preliminary plan and is prepared by the logging manager or logger usually just before the harvesting operation begins. Virginia's BMP manual goes on to give fourteen steps to developing a comprehensive plan (Virginia Department of Forestry). Several other southern states give detailed guidelines for pre-harvest planning while others simply imply that planning is important.

Timber harvesting guidelines include recommendations for several different activities in addition to just the cutting down of trees. Some of the harvesting BMP guidelines included by southern states cover: felling of timber, skidding or transporting the harvested timber, location and maintenance of landing areas, and trash disposal. Most BMP recommendations for timber harvesting are descriptive.

Since the actual felling of trees can impact the forest site and potentially affect water quality several southern states have recommendations for felling.

Recommendations for felling are descriptive and generally involve harvesting near a water body. States that provide guidelines for felling timber discourage felling directly into water bodies unless completely unavoidable. The practice of directional felling is recommended so as to minimize the amount of debris that may enter a stream (Oklahoma Forestry Commission, Louisiana Department of Agriculture and Forestry).

After timber is felled it usually must be transported to a loading or landing area, usually by skidding the logs. Skidding usually requires the logs to be dragged across the ground using heavy equipment, which can affect soil stability and cause rutting, puddling of water, or compaction of the soil (Georgia Forestry Commission 1999). All of these potential impacts from skidding can increase the possibility for erosion. Forwarders carry logs in a bunk off the ground, but are rarely used in the South.

Most forest sites contain hills and slopes, which can provide additional problems when skidding. The slope of a skid trail can affect the potential for erosion and impact water quality. States generally give recommendations for location of skid trails and suggest that if skid trails must be located on a slope, to conduct skidding uphill. Some southern states recommend making breaks in the grade for steep slopes and even placing logging slash on the trails to help reduce erosion (Alabama Forestry Commission 1993, Arkansas Forestry Commission 2002).

The closing or retirement of skid trails when harvesting operations are completed is important for insuring that erosion from skid trails is minimized after use. Use of water bars are recommended by most states for reducing future sedimentation. Also, use of logging slash or seeding of the skid trails is recommended to stabilize the exposed soil left after skidding has been completed. Other measures or techniques for stabilizing skid

trails may be recommended by southern states as well (Louisiana Department of Agriculture and Forestry, Texas Forestry Commission).

The primary destination of most skidding operations is a logging deck or landing. A logging deck or landing is “a place where logs are gathered in or near the forest for further transport” (North Carolina Division of Forest Resources 1989). These areas are included in BMP recommendations because of the high volume of heavy equipment traffic and the high potential for soil disturbance, rutting, and soil compaction. Recommendations for logging decks generally focus on location and retirement after harvesting is completed. Generally states recommend locating logging decks on firm ground with good natural drainage so as not to increase rutting or promote puddling. Like skid trails most states recommend stabilizing logging decks and landings after harvesting is completed to help reduce the potential for erosion and water quality impacts (Alabama Forestry Commission 1993, Arkansas Forestry Commission 2002).

Harvesting operations produce waste such as logging slash and other natural debris. The use of equipment for harvesting requires regular maintenance, which may involve lubricants, fuels and other chemicals being used at the forest site. Overall, the operation will generate trash that must be disposed of properly. States provide general guidelines for disposal of trash. Most states recommend the removal of logging debris from streams and discourage using any waterbody as a place to discard waste of any kind. Many southern states discourage placing logging debris or trash in SMZs. The burning or burial of waste onsite is usually discouraged (Alabama Forestry Commission 1993, Arkansas Forestry Commission 2002, Louisiana Department of Agriculture and Forestry, Mississippi Forestry Commission 2000, North Carolina Division of Forest Resources



1989, Oklahoma Department of Agriculture, Forestry Services, Texas Forestry Commission).

Some of the guidelines for timber harvesting activities for southern states are shown in

Table 9.

**Table 9. BMP Guidelines for Timber Harvesting**

<b>State</b>	<b>Felling and/or Bucking</b>	<b>Skidding/Transporting</b>	<b>Landing Areas</b>	<b>Trash Disposal</b>
Alabama	<ul style="list-style-type: none"> <li>-Should be conducted carefully to minimize impact of subsequent phases of logging operations on water quality.</li> <li>-For timber harvesting in SMZs, follow SMZ guidelines.</li> </ul>	<ul style="list-style-type: none"> <li>-Do not use stream channels or natural drainages as skid trails.</li> <li>-Skidding should be conducted so as to minimize impacts from rutting, compaction, and puddling on water quality and excessive soil displacement and disruption of natural drainages.</li> <li>-Trails on steep slopes should have occasional breaks in grade and water bars installed upon completion of use.</li> <li>-Use logging slash to help reduce erosion or stabilize temporary landings.</li> </ul>	<ul style="list-style-type: none"> <li>-Should be planned before operation begins.</li> <li>-Landings should be kept as small as possible.</li> <li>-Must be located on firm ground, outside of SMZ, and above the ordinary high water mark of streams.</li> </ul>	<ul style="list-style-type: none"> <li>-Should be in accordance with all applicable laws.</li> <li>-Fuel, lubricants, and other toxic chemicals must never be drained into the soil.</li> <li>-Food and drink containers, discarded equipment parts and used fluids must be properly removed and disposed of.</li> <li>-Trash must not be burned or buried on site.</li> </ul>
Arkansas	<ul style="list-style-type: none"> <li>-Fell trees away from stream to minimize the amount of debris entering the stream.</li> <li>-Fell trees parallel to the skidding direction with the butt of the log toward the landing.</li> </ul>	<ul style="list-style-type: none"> <li>-Locate skid trails to minimize disruption of natural drainage patterns.</li> <li>-Do not use stream channels as skid trails.</li> <li>-Where stream crossings cannot be avoided, use most direct route possible. Always take advantage of natural fords.</li> <li>-Remove temporary crossings as soon as possible after use.</li> <li>-Locate skid trails so they do not run parallel to any stream when trails are within the average high water level of the stream.</li> <li>-Skid trails on slopes should have occasional breaks in grade to facilitate dispersal of water.</li> <li>-Water-bar and seed skid trails when not in use.</li> <li>-When cable-yarding across streams cannot be avoided, leave streamside vegetation as undisturbed as possible.</li> </ul>	<ul style="list-style-type: none"> <li>-Locate landings to minimize any impact skidding may have on the natural drainage pattern.</li> <li>-Locate landings on firm ground outside SMZs.</li> <li>-Locate landings to take advantage of natural drainage patterns to disperse water into the forest floor.</li> <li>-When harvesting operations are completed, make sure water is dispersed from landings and roads.</li> <li>-Locate landings for barge loading and transportation of logs to comply with Corps of Engineers regulations.</li> <li>-Provide shade, soil stabilization, and filter strips of vegetation along streams (potential methods provided in manual).</li> </ul>	<ul style="list-style-type: none"> <li>-Remove logging debris that is deposited in streams.</li> <li>-Scatter debris on landings away from drainages or streams.</li> <li>-Mulch or seed erosion prone areas and natural drainage channels to help reestablish permanent vegetative cover.</li> <li>-Keep logging litter, such as oil cans, grease containers, crankcase oil filters, old tires, broken cable, paper and other trash, out of streams. Haul this kind of trash to a legal landfill.</li> </ul>

			-Where difficult to leave adequate vegetation within SMZ to afford stream protection, reestablish cover as soon as possible after harvesting.	
Florida	N/A	<ul style="list-style-type: none"> <li>-Locate skid trails along the contour whenever practical to promote revegetation and reduce soil erosion.</li> <li>-Skid uphill and avoid long, continuous skid trails.</li> <li>-After skidding activities are complete, stabilize skid trails where necessary by installing water bars or similar structures at recommended intervals.</li> <li>-Seeding and fertilizing skid trails will accelerate stabilization on erodible soils and/or steep slopes.</li> <li>-When skidding in muck or peat soils, concentrate skidding to as few trails as possible.</li> <li>-When skidding on mineral soils, skidding should be dispersed so that soil compaction is minimal even in individual trails.</li> <li>-Keep main skid trails out of all SMZs except to approach a designated crossing.</li> </ul>	N/A	<ul style="list-style-type: none"> <li>-Logging slash may be left in place as long as material is not left in water body.</li> <li>-Remove logging slash from all water bodies including both intermittent and perennial streams, lakes and sinkholes.</li> <li>-Do not pile or push logging slash into cypress ponds or strands, swamps, marshes, grassy ponds, or water bodies such as streams, lakes, sinkholes or similar water resource features.</li> </ul>
Georgia	N/A	<ul style="list-style-type: none"> <li>-Skid uphill to log decks on ridges or hills.</li> <li>-Have periodic breaks in grade to help disperse surface flow.</li> <li>-Use temporary closure techniques; such as water bars or covering with logging slash, if significant erosion may occur before permanent closure techniques are installed.</li> <li>-Where needed, retire as soon as possible with properly installed water control structures.</li> <li>-When grades exceed 15%, use water bars with water turnouts.</li> <li>-Avoid trails over 40% grade except for short stretches.</li> <li>-Avoid bladed trails unless required on side slopes to</li> </ul>	<ul style="list-style-type: none"> <li>-Locate log decks before planning road system.</li> <li>-Minimize the number of log decks necessary for the operation.</li> <li>-Minimize the size of log decks.</li> <li>-Locate log decks uphill and skid up to them.</li> <li>-Locate log decks in a stable, well-drained area away from gullies when possible.</li> <li>-Stabilize, as needed when the harvest is completed, using water bars, logging slash, or vegetative cover.</li> <li>-Avoid locating log decks in SMZs.</li> <li>-Avoid allowing log decks to concentrate</li> </ul>	N/A

		<p>create that appropriate grade for safe operations.</p> <ul style="list-style-type: none"> <li>-Avoid using stream and drains with defined channels as skid trails.</li> <li>-Avoid main skid trails within SMZs.</li> </ul>	<p>storm runoff onto roads, trails, or direct paths leading to a watercourse.</p>	
Kentucky	N/A	N/A	N/A	N/A
Louisiana	<ul style="list-style-type: none"> <li>-When possible, trees should be directionally felled away from water bodies.</li> <li>-Remove only tops and limbs, which have fallen into any water body during harvesting.</li> <li>-Inspect all stream courses to be sure they are free from excessive logging debris.</li> </ul>	<ul style="list-style-type: none"> <li>-Use soil surveys, aerial photographs, and topographic maps to help locate skid trails.</li> <li>-Use the smallest number, width and length of skid trails needed to log the area effectively.</li> <li>-Use waterbars, wing ditches, or other appropriate practices to slow and disperse water runoff. Construct waterbars to divert water rather than block it.</li> <li>-Keep stream crossings to a minimum.</li> <li>-Cross streams at right angles and in straight sections of the stream, when practical.</li> <li>-Skid logs uphill at an angle.</li> <li>-Scatter logging slash on wetter areas of skid trails to prevent rutting.</li> <li>-Keep skidder loads light in sensitive areas to reduce rutting and protect drainage integrity.</li> <li>-Stabilize skid trails to prevent erosion by using waterbars, logging slash, or other appropriate water diversions.</li> <li>-Establish vegetative cover after smoothing and shaping of bare ground subject to erosion.</li> <li>-When crossing streams, temporary fills should be removed in their entirety after completion of harvesting operations.</li> <li>-Restore stream crossings to natural grade and shape.</li> <li>-Avoid sensitive areas and problem soils.</li> <li>-Avoid skidding straight up or down steep slopes.</li> <li>-Avoid long, steep skids. Lay out skid trails on slopes at an angle to break up the grade.</li> </ul>	<ul style="list-style-type: none"> <li>-Use no more sets than are necessary.</li> <li>-Make sets no larger than necessary.</li> <li>-Locate sets on firm, well-drained ground away from streams.</li> <li>-Locate log sets on a slight slope (less than 5%) for drainage whenever possible.</li> <li>-Locate sets so skidding will have a minimal impact on the natural drainage pattern.</li> <li>-Locate sets where skidding will avoid road ditches, sensitive sites, and excessive slopes.</li> <li>-Reshape disturbed areas to minimize soil erosion.</li> <li>-Seed and fertilize bare areas that would erode before natural vegetation is re-established.</li> <li>-Avoid locating log decks in SMZs or other sensitive areas.</li> <li>-Avoid locating log decks where they might result in skidding through sensitive areas.</li> </ul>	<ul style="list-style-type: none"> <li>-Capture all coolants, oils, fuels, etc. and dispose of waste properly.</li> <li>-Properly dispose of all trash associated with harvesting.</li> <li>-Do not burn or bury trash.</li> </ul>

		<ul style="list-style-type: none"> <li>-Avoid water draining down skid trails.</li> <li>-Avoid skidding in a stream channel even when temporarily dry.</li> <li>-Avoid skidding across perennial streams or large intermittent streams unless it is done with a properly constructed temporary crossing.</li> <li>-Avoid excessive damage to remaining timber and other vegetation within SMZs.</li> <li>-Avoid using existing skid trails if further use will cause excessive soil disturbance.</li> </ul>		
Mississippi	N/A	<ul style="list-style-type: none"> <li>-Locate trails to serve the intended purpose while facilitating adequate control of surface water and sedimentation.</li> <li>-Use procedures that will promote the quickest healing of skid trails.</li> <li>-Conduct skidder logging on the contour as much as possible.</li> <li>-Skid uphill when skidding must be done against the contour.</li> <li>-Hold the number of trips on the same skid trail to a minimum.</li> </ul>	<ul style="list-style-type: none"> <li>-Locate a landing or concentration yard on a site, which will not present an erosion and subsequent siltation problem.</li> <li>-Leave an adequate SMZ between landings and watercourses.</li> <li>-Landings and yards should have a slight slope to allow drainage.</li> <li>-Provide for adequate drainage on approach roads so that road drainage water does not enter the landing area, causing muddy, wet conditions.</li> <li>-Provide for stabilization of landings immediately following the completion of operations.</li> </ul>	<ul style="list-style-type: none"> <li>-Drain equipment fluids into containers and dispose of according to label directions.</li> <li>-Dispose all empty containers in the same manner.</li> </ul>
North Carolina	N/A	<ul style="list-style-type: none"> <li>-Skidding activity should be concentrated as much as possible on a few primary skid trails.</li> <li>-Avoid random dispersed skidding.</li> <li>-Skid trails should follow contours on steep terrain where possible and should not exceed grades of 25%.</li> <li>-Water control practices should be installed on primary skid trails.</li> <li>-Climbing primary skid trails should proceed upslope on a slant or zig-zag pattern,</li> </ul>	<ul style="list-style-type: none"> <li>-Landings and decks should be located away from streams and on elevated sites.</li> <li>-Locate sites for decks in advance of road construction.</li> <li>-Locate log decks outside of SMZs.</li> <li>-Locate decks and landings on sloping sites to provide good drainage.</li> <li>-Plan for good drainage on road and trail approaches to deck so that surface water will not</li> </ul>	<ul style="list-style-type: none"> <li>-Servicing equipment onsite should be done in such a way that waste oil, etc. will be collected and disposed of in accordance with disposal regulations.</li> <li>-Garbage and trash should be removed and disposed of properly.</li> <li>-Locate residue piles (sawdust, slabs, etc.) outside of ephemeral stream areas so that water from residue will not drain directly into adjacent streams or waterbodies.</li> </ul>

		<p>breaking the grade and avoiding long steep grades.</p> <ul style="list-style-type: none"> <li>-Timber should be skidded uphill either to a contour primary skid trail or to more level ground.</li> <li>-Confine any downhill skidding to low gradient slopes and upper slope positions.</li> <li>-Locate skid trails outside of SMZs.</li> <li>-It is permissible to cross dry intermittent and ephemeral streams with dispersed skidding if the root mat is protected and not destroyed.</li> <li>-Skidding should not follow the natural drainway of a dry hollow.</li> <li>-Approaches to water crossing should be as near right angles to stream as possible.</li> <li>-Trees cut within SMZs should be cabled out by equipment stationed outside the SMZ.</li> <li>-Avoid felling trees across or into streams.</li> <li>-State law prohibits stream obstruction by logging slash or other debris.</li> <li>-Skidding should cease when the soils are wet enough to cause excessive soil compaction.</li> </ul>	<p>drain onto deck areas and cause ponding and mud holes.</p> <ul style="list-style-type: none"> <li>-If subsurface or surface flow is entering a deck area, construct a diversion ditch around the uphill side to intercept the flow of water and direct it away from the deck and watercourses.</li> <li>-Where large bare ground areas exist, provide ground cover on decks, landings and portable mill sites following completion of harvesting operations.</li> </ul>	
Oklahoma	<ul style="list-style-type: none"> <li>-Trees should not be felled into streams except for those trees that cannot otherwise be practically and safely felled outside the stream. Such trees should be removed promptly.</li> <li>-Directional felling should be practiced near perennial streams to minimize debris entering the stream, to facilitate disposal of logging debris and to reduce damage to residual trees in partial cuts.</li> <li>-Felling trees parallel to the skidding direction with butts toward the landing to the extent feasible can facilitate skidding and minimize soil disturbance.</li> </ul>	<ul style="list-style-type: none"> <li>-Harvest operations should match available equipment with the terrain, soils, and weather conditions to minimize soil compaction and disturbance.</li> <li>-Skid trails should be laid out to avoid disrupting natural drainage channels, to take advantage of topography, to minimize steep gradients and to keep soil displacement to a minimum.</li> <li>-Where practical, skidding should be upslope or on the contour to disperse downhill water flow.</li> <li>-Stream channels should not be used as skid trails.</li> <li>-Crossings of streams should</li> </ul>	<ul style="list-style-type: none"> <li>-Landings should be located to minimize adverse impact of skidding on the natural water drainage pattern.</li> <li>-Landings, if possible, should be on firm ground outside SMAs of perennial streams and above the ordinary high water mark of intermittent streams.</li> <li>-Location should take advantage of topography to minimize accumulation of water on the landing and to permit diversion of water onto the forest floor.</li> <li>-Landings should be kept</li> </ul>	<ul style="list-style-type: none"> <li>-Logging debris, which is accidentally deposited in streams, should be removed during harvest operations.</li> <li>-Logging debris accumulations in intermittent streams which have potential for blocking the stream or for subsequent slide or debris avalanche occurrence should be removed from the channel in conjunction with harvest operations.</li> <li>-Debris accumulations on the remaining harvested area should be scattered to the maximum extent possible during harvest</li> </ul>

		<p>be minimized with the direction of log movement between streambanks kept as close to a right angle to the stream channel as practical.</p> <ul style="list-style-type: none"> <li>-The number of skidding routes through SMAs should be minimized; avoid using skidding equipment in SMAs.</li> <li>-Under story vegetation along banks of perennial streams should be left undisturbed to the maximum degree possible to protect the integrity of streambanks.</li> <li>-Any felled or downed tree in a flowing stream should be promptly removed. To the extent practical, the entire tree should be skidded out of the stream or SMA prior to limbing and bucking.</li> <li>-Skid trails on slopes should have occasional breaks in grade to facilitate diversion of water. Upon completion of use, trails should be water-barred when necessary to prevent soil erosion.</li> <li>-Servicing of equipment should be carried out away from streams, and fuel and lubricant storage tanks or containers should be located where an accidental spill would not result in stream contamination.</li> </ul>	<p>to the smallest size compatible with efficient and safe logging operation.</p> <ul style="list-style-type: none"> <li>-When the operation is completed, any impounded water on or around the landing should be drained and provision made for diversion of any water flowing down the road into or away from the landing.</li> </ul>	<p>operations unless site preparation plans for the area indicate otherwise.</p> <ul style="list-style-type: none"> <li>-Where feasible, scattering of limbs and logging debris on skid roads and exposed soil areas will retard water flow and reduce soil movement.</li> <li>-Debris on landings should be piled where burning is anticipated and should not be shoved into drainages or streams.</li> <li>-Erosion-prone areas can be mulched or seeded to help establish permanent vegetative cover.</li> <li>-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. All debris should be hauled to designated, legal disposal sites.</li> </ul>
South Carolina	N/A	<ul style="list-style-type: none"> <li>-Avoid skidding beside or within a stream channel.</li> <li>-Avoid skidding straight up and down (perpendicular to the contour) on steep hillsides if mineral soil is exposed. Use BMPs such as water bars, soil stabilization, etc., where this type of skidding is unavoidable.</li> </ul>	<ul style="list-style-type: none"> <li>-Avoid locating log decks in sensitive areas.</li> </ul>	N/A
Tennessee	N/A	<ul style="list-style-type: none"> <li>-Avoid operating skidders in SMZs.</li> </ul>	<ul style="list-style-type: none"> <li>-Locate landings above and away from streams.</li> <li>-Revegetate landings following logging operations.</li> <li>-Select the locations of log landings before harvesting begins.</li> <li>-Construct landing sites</li> </ul>	N/A

			with slope enough to drain properly but not exceeding 5 percent.	
Texas	<p>-Directional felling should be used near streams to minimize debris entering the stream. Trees on stream banks within the SMZ should be left to provide shade and to stabilize the stream bank. Any tree that cannot be felled without falling into or across the streambed should be left standing.</p> <p>-Trees should be removed from the SMZ before being limbed and topped if the adjacent areas are to be burned after logging operations.</p> <p>-Every effort should be made to protect the residual timber stand within the SMZ.</p>	<p>-Skid trails should be placed to minimize disruption of natural drainage patterns.</p> <p>-Stream channels, road ditches, or roads (primary or secondary) should not be used as skid trails.</p> <p>-Where stream crossings cannot be avoided, use natural fords with firm bottoms, stable banks, and gentle slopes along approaches.</p> <p>-Temporary crossings using culverts, poles, or portable bridges should be removed and the site restored as soon as their use is complete.</p> <p>-Skid trails on slopes should have occasional breaks in grade to vent water. Upon completion of use, and if necessary, trails should be waterbarred and seeded to prevent excessive soil erosion.</p> <p>-When winching across streams cannot be avoided, streamside vegetation should be left undisturbed as much as possible.</p> <p>-Service equipment away from streams so accidental spillage won't result in stream contamination.</p> <p>-Erosion prone areas should be mulched or seeded to help reestablish permanent vegetative cover when necessary.</p>	<p>-Locate sites for decks and portable mill locations in advance of road construction.</p> <p>-Locate portable mills and sets at least 50 feet from the edge of the SMZ.</p> <p>-Sets and yards should have a slight (2 to 5%) slope to permit drainage and should be sited on well-drained soils, which dry quickly.</p> <p>-Provide adequate drainage on approach roads and trails so that runoff does not drain onto the set area and cause "mud holes".</p> <p>-A diversion ditch around the uphill side of decks can intercept the flow of water and direct it away from the deck.</p> <p>-Equipment serviced on-site should have waste oil etc. drained into containers properly disposed of in accordance with current waste disposal recommendations. Garbage and trash shall be likewise removed and properly disposed of.</p> <p>-Locate residue piles outside of wet weather drainages so that drainage water from residue will not drain into streams or other bodies of water.</p> <p>-Disturbed areas should be reshaped to provide adequate surface drainage. Revegetate decks, landings, and portable mill locations within the first 15 days of the next seeding season following completion of harvesting operations.</p>	<p>-Logging debris in streams should be removed immediately.</p> <p>-Debris from landings should not be pushed into drains, streams, or SMZs.</p> <p>-All trash associated with the logging operation should be promptly hauled (not buried) to a legal disposal site.</p> <p>-All equipment fluids shall be captured and disposed of properly.</p>
Virginia	N/A	-Locate log landings away from SMZ first and design	-Locate sites for decks and portable mill	-Do not allow engine fluids to be drained onto the

		<p>skidding approaches with grades less than 15%.</p> <ul style="list-style-type: none"> <li>-Gradients should not be steeper than 50/10 with exception that steeper segments may be required to avoid boundary lines, sensitive areas, or other areas not accessible using skid roads of lesser grades. When skidding is dispersed and mineral soil is not exposed steeper grades may be used. If steeper grades are necessary, practices must be used to prevent concentrated water flow near water courses. If it is possible to limit exposure of mineral soil, alternate systems should be considered such as extra cable length on skidders or cable yarding.</li> <li>-Any skid trail which must cross a perennial or intermittent stream, or a drainage ditch that leads to natural drainage should use an appropriately selected and installed structure.</li> <li>-Logs should not be skidded through perennial or intermittent streams.</li> <li>-Approaches to water crossings should be as near to right angles to the stream direction as possible.</li> <li>-Climb upslope on a slant or zig-zag pattern to break the grade whenever possible.</li> <li>-Skidding is discouraged when soils are saturated to prevent excessive soil compaction and channel erosion.</li> <li>-Upon completion of skidding, areas subject to erosion should have water bars installed immediately.</li> <li>-Water bars should be installed at a 30 to 45 degree angle downslope with ends open to prevent water accumulation behind them.</li> <li>-A permanent vegetative cover should be established on exposed roads, trails and landings greater than 5 percent</li> </ul>	<p>locations in advance of road construction.</p> <ul style="list-style-type: none"> <li>-Locate portable mills and decks at least 50 feet from an SMZ.</li> <li>-Prevent stormwater runoff from decks, landings and mill sites from entering stream channels.</li> <li>-Decks and yards should have a slight (2 to 5 percent slope) to allow for drainage and should be on well-drained soils, which dry out quickly.</li> <li>-A diversion ditch around the uphill side of decks can intercept the flow of water and direct it away from the deck.</li> <li>-Keep site clean and free of trash.</li> <li>-Disturbed areas should be reshaped to provide adequate surface drainage. Revegetate decks, landings, and portable mill locations following completion of harvesting operations using appropriate methods and materials.</li> </ul>	<p>ground when servicing equipment. Maintain equipment to control leakage of hydraulic fluids, antifreeze, and similar substances. Provide proper storage and removal for fuel, used oil and other oils.</p> <ul style="list-style-type: none"> <li>-Do not leave trash on the site when the harvest is complete.</li> <li>-Locate sawdust piles and slab piles outside of wet weather drainages and SMZs so that water from residue will not drain into adjacent streams or bodies of water.</li> </ul>
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### ***Site Preparation and Reforestation***

Site preparation and reforestation are important in enhancing the productivity of forests, reducing the generation gap, and improving environmental protection of woodlands (North Carolina Division of Forest Resources 1989). Two of the most important reasons, specific to water quality, for proper site preparation and regeneration are (1) reducing soil erosion and (2) preventing sedimentation (North Carolina Division of Forest Resources 1989).

Site preparation may be intended for either natural regeneration or artificial regeneration of trees by direct seeding or planting. There are several activities that fall under site preparation and reforestation. State BMP manuals differ in which activities they choose to include in their guidelines and how much detail is given. Some states provide general guidelines for site preparation and/or include specific practices. Which forms of site preparation a state includes in its' BMP manual may depend on several factors. The cost of using a method and the soil types, tree species, vegetation, and variation in slope within the state influence which site preparation methods are given recommendations (Georgia Forestry Commission 1999, Louisiana Department of Agriculture and Forestry).

Site preparation may include both mechanical and chemical methods. Specific site preparation practices covered under southern state BMP guidelines include: bulldozing, shear-blading (or shearing), drum chopping, disking, furrowing, prescribed burning, and chemical application (Mississippi Forestry Commission 2000, North Carolina Division of Forest Resources 1989).

### Mechanical

Mechanical site preparation usually consists of three main types of physical activity: (1) breaking or grinding the vegetation on site, (2) removal of the vegetation from the site, and (3) manipulating the soil (Florida Department of Agriculture and Consumer Services). Guidelines for mechanical methods for site preparation are included in every southern state BMP manual. Because mechanical preparation involves disturbing the ground on a site, factors such as the topography, remaining ground cover, and soil type are important in assessing which type of site preparation methods to use.

A mechanical preparation method is usually categorized in reference to its impact on the soil. Certain methods may have a high or low impact on the soils of a forest site. Methods such as disking and bedding are considered high impact due to the large percentage of bare soil that is exposed during these operations. More than 50% of a site's soil may be exposed using disking or bedding. High impact methods are usually only recommended for flat or gently sloping sites. Low impact mechanical site preparation methods are usually used on terrain with modest to steeper slopes. Chopping is an example of a mechanical site preparation method that is considered low impact to the soil (Georgia Forestry Commission 1999, South Carolina Forestry Commission).

BMP guidelines for mechanical site preparation may give specific recommendations for particular methods or general recommendations depending on the state. For example, Tennessee gives guidelines for mechanical preparation, but does not break the practices down by method. An example of a Tennessee BMP recommendation for site preparation is "Avoid mechanical methods on sites whose slopes exceed 30 percent" (Tennessee Department of Agriculture, Division of Forestry).

North Carolina and Oklahoma provide recommendations for specific practices. Oklahoma gives recommendations for shearing, K-G blading, piling, chopping and brush crushing, disk-harrowing, bedding, furrowing, ripping as well as for site drainage (Oklahoma Department of Agriculture, Forestry Services). North Carolina has guidelines for chopping, disking, bulldozing, i.e. windrow construction, raking and piling, bedding, furrowing and scalping and for use of hand tools and machine planting (North Carolina Division of Forest Resources 1989). Having recommendations for specific methods

may help forest owners decide on options better suited to their land characteristics. Table 10 shows many of the BMP guidelines for mechanical site preparation for southern states.

**Table 10. BMP Guidelines for Mechanical Site Preparation**

State	Shearing	Drum Chopping	Disking	Prescribed Burning	Additional Comments
Alabama	-Requires that operator keep the blade out of the soil to minimize soil disturbance.	-On steep slopes, go up and down hill so sediment can be trapped in slits created by chopper blades	-Should be done on contour and to areas with slopes 10% or less.	-Constructed firebreaks can be tied into existing natural barriers. -Fire breaks should be stabilized with water diversion devices.	-No mechanical site preparation in SMZs. -Mechanical site preparation should be avoided on soils with slopes exceeding 25%. -Bedding on slopes exceeding 2% should follow the contour. On slopes 2% or less, beds should follow the natural drainage of the land. -Ripping and/or subsoiling should be done on the contour. -Straight blade bulldozing is the least desirable method of mechanical site preparation.
Arkansas	N/A	N/A	-Avoid disking on steep slopes and on slopes with thin or highly erodible soils.	N/A	-Minimize use of equipment in SMZs -Minimize disturbance of areas near streams or other bodies of water.
Florida	-Keep shearing blade above the soil surface.	-Position chopper perpendicular to waterbody to orient soil indentations along the contour when chopping. (unless chopping is followed by bedding or if waterbody is separated from chopped area by a barrier to overland flow.	N/A	-Do not perform site preparation burn within SMZ when slopes exceed 18%. -Burning for ecological purposes on steep slopes is not restricted.	-No mechanical site preparation within SMZ.
Georgia	N/A	-Should be conducted perpendicular to the slope.	N/A	N/A	N/A
Kentucky	N/A	N/A	-Should be operated along contour.	-Burn only with trained crews under carefully prescribed conditions of humidity, temperature, and	-When possible, confine mechanical methods to slopes less than 30 percent. -Minimizing the creation of bare soil while

				<p>wind.</p> <ul style="list-style-type: none"> <li>-Fire lines should be planned and constructed before burning to assure burning will be confined to the prescribed area.</li> <li>-Should construct water bars on fire lines in hilly or steep terrain.</li> <li>-When potential for water pollution exists, should make provision for an adequate strip of undisturbed surface between the prescribed burn and perennial and intermittent water courses.</li> </ul>	<p>achieving the desired results should be a consideration in determining site preparation methods.</p> <ul style="list-style-type: none"> <li>-Use low-impact methods to facilitate tree planting when possible to minimize potential for nonpoint source pollution.</li> <li>-Avoid operating heavy equipment during wet weather to minimize soil disturbance, primarily rutting and compaction.</li> </ul>
Louisiana	-Ripping, shearing, windrowing, and mechanical planting should follow the contours of the land	N/A	N/A	N/A	N/A
Mississippi	-Follow contours of land	-Not necessary to follow contours of land	-Follow contours of land	<ul style="list-style-type: none"> <li>-Keep out of SMZs</li> <li>-Eliminate extremely hot prescribed burns</li> </ul>	N/A
North Carolina	N/A	-On slopes >10% direction of travel should be based on safe equipment operations.	<ul style="list-style-type: none"> <li>-Disk parallel to contour lines.</li> <li>-Schedule operations during favorable soil moisture conditions.</li> <li>-Do not disk within SMZs or near ephemeral streams.</li> </ul>	<ul style="list-style-type: none"> <li>-Construct firelines where necessary along perimeter of burn area and along perimeter of SMZs.</li> <li>-Construct firelines in accordance with guidelines for logging trails and skid trails with respect to water bars and turnouts.</li> <li>-Keep firelines out of salt marshes, critical wetlands, and riparian areas.</li> <li>-No burning in SMZ if aerial or broadcast spraying of herbicides is applied to SMZ.</li> <li>-In steep terrain construct firelines by hand instead of</li> </ul>	-No debris of any kind or soil will be placed in intermittent or perennial streams.

				heavy equipment.	
Oklahoma	<ul style="list-style-type: none"> <li>-Protect SMAs and intermittent stream channels by planning equipment operation to minimize soil disturbance in these areas.</li> <li>-Use care in equipment operation to minimize soil disturbance and displacement.</li> <li>-Windrows and their spacing should be such that soil exposure and soil movement is minimized.</li> <li>-On slopes, locate windrows on the contour.</li> <li>-Keep soil in windrows to a minimum.</li> <li>-If at all possible, windrows should not be placed in SMAs or intermittent stream channels.</li> </ul>	N/A	<ul style="list-style-type: none"> <li>-Avoid complete disking of steep slopes with extremely erodible soils. Disking of alternate strips on the contour may be an acceptable practice on certain side slopes.</li> <li>-Provide water outlets on bedded or furrowed areas at locations that will minimize movement of sediment.</li> <li>Wherever possible, discharge water onto vegetated surfaces.</li> </ul>	<ul style="list-style-type: none"> <li>-Firelines constructed during planned prescribed burning activities, or routine fire protection, should be water-barred immediately.</li> <li>-On steeper slopes r seed on bare areas if possible.</li> </ul>	<ul style="list-style-type: none"> <li>-All site preparation methods should be conducted so as to:               <ol style="list-style-type: none"> <li>1) minimize soil displacement or compaction,</li> <li>2) minimize soil erosion on slopes and sediment movement into waters; and</li> <li>3) prevent accumulation of debris in creek bottoms, ponds, streams or rivers.</li> </ol> </li> </ul>
South Carolina	<ul style="list-style-type: none"> <li>-Minimize moving soil into windrows and piles.</li> </ul>	N/A	N/A	N/A	<ul style="list-style-type: none"> <li>-On slopes 5% or less, any method may be used.</li> <li>-Avoid any mechanical methods on slopes greater than 30%.</li> <li>-Avoid mechanically preparing sites when equipment will cause excessive soil disturbance due to saturated or very wet soil conditions.</li> <li>-Avoid intensive mechanical methods on slopes greater than 20% or on other sites with high potential for erosion.</li> </ul>
Tennessee	N/A	N/A	N/A	<ul style="list-style-type: none"> <li>-Construct firelines on the contour in advance of prescribed burning.</li> <li>-Plow firelines as shallow as possible to minimize soil disturbance.</li> </ul>	<ul style="list-style-type: none"> <li>-Carry out all mechanical site preparation operations and tree planting along the contour of the land.</li> <li>-Avoid mechanical methods on sites whose slopes exceed 30 percent.</li> <li>-Avoid clearing uphill on</li> </ul>

				-Construct water bars and wing ditches at recommended intervals on firelanes to turn water into adjacent undisturbed areas. -Avoid prescribed burning on excessively steep slopes and highly erodible soils.	steeper grades to prevent water channeling in tractor tracks. -Avoid operating heavy equipment during wet periods.
Texas	N/A	N/A	N/A	N/A	-Ripping, shearing, windrowing, and mechanical planting should follow the contour. -Soil disturbance should be kept to a minimum. Avoid intensive site preparation on steep slopes and on slopes with thin or highly erodible soils. -Site preparation activities should skirt SMZs and stream channels. Any debris should be placed above the ordinary high water mark of any stream, or body of open water. -Provide water outlets on bedded or furrowed areas at locations that will minimize movement of soil. Discharge water onto a vegetated surface.
Virginia	N/A	N/A	N/A	N/A	N/A

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## Chemical

Chemicals have several uses in forest management. One of the major uses of chemicals is for site preparation or reforestation. For this report the broad term chemicals refers to pesticides and fertilizers. Herbicides are the most commonly used pesticides in forest management. Some rodenticides are used, but generally unwanted vegetation, insects and fungi are the intended targets when using pesticides (North Carolina Division of Forest Resources 1989).

Guidelines for chemical use are given by 11 of the 13 southern states. These guidelines are created to help keep chemicals from reaching streams and other water sources. Tennessee and Virginia are the two states that do not provide guidelines for chemical use in their BMP manuals. In addition, several states do not include guidelines specific for fertilization in their BMP manuals when covering chemical use.

Due to the difference in chemical needs and use between states, some state BMP guidelines include more detail. Pesticides and fertilizers come in different physical forms including liquid, powder, and granular. Chemical application may be conducted aerially or by using ground equipment. Some states, including North Carolina and Oklahoma,



include guidelines for both aerial and ground application while other states provide broader guidelines intended to cover all application methods (Oklahoma Forestry Commission, North Carolina Division of Forest Resources 1989).

In addition to application methods, BMP guidelines for chemical use may cover equipment clean up, container disposal, maintenance of equipment, transporting, handling, and mixing of chemicals. Most guidelines give general statements such as “Label containers according to state and federal regulations” (Arkansas Forestry Commission 2002). Some states provide specific guidelines for application of chemicals. For example in North Carolina, “fertilizer may be broadcast no closer than 25 feet of open water or perennial streams” (North Carolina Division of Forest Resources 1989). Table 11 provides a summary of the important BMP guidelines pertaining to chemical application for southern states.

<b>Table 11. BMP Guidelines for Chemical Application.</b>		
<b>State</b>	<b>Pesticide</b>	<b>Fertilizer</b>
Alabama	-Application must follow manufacturer’s label instructions, EPA guidelines, and Alabama State Law. -Not allowed within SMZs.	-Not allowed within SMZs
Arkansas	-Chemicals should not leak from equipment used for transportation, storage, mixing or application. -Mix chemicals and clean tanks only where possible spills will not enter streams, lakes or ponds. -Carefully plan application to avoid direct and indirect entry of chemicals into streams and impoundments, recognizing that portions of an SMZ may be left untreated. -Chemicals should not be applied where stream pollution is likely to occur. -Application must follow manufacturer’s label instructions, EPA guidelines, and state and federal requirements.	N/A
Florida	-Should not be applied anywhere within the Primary Zone.	-Fertilizers must not be applied within the Primary or Secondary Special Management

	<ul style="list-style-type: none"> <li>-Containers should not be left on site.</li> <li>-Do not rinse spray equipment or discharge rinse water into any water body, wetland, or within SMZ.</li> <li>-Equipment that applies chemical directly onto target area should be used.</li> </ul>	<p>Zones.</p> <ul style="list-style-type: none"> <li>-Consider the use of slow release fertilizer when conditions are appropriate.</li> </ul>
Georgia	<ul style="list-style-type: none"> <li>-Establish appropriate SMZ along perennial and intermittent streams and flowing bodies of water.</li> <li>-Consider weather conditions, equipment capabilities, and pesticide formulations to avoid pesticide drift into the SMZ.</li> <li>-Conduct all pesticide handling away from waterbodies, wells, and roadside ditches.</li> <li>-Dispose of pesticide containers/excess pesticide according to local, State, and Federal regulations and label requirements.</li> <li>-Clean up/contain spills immediately. Report spills to GA EPD Emergency Response Program.</li> </ul>	<ul style="list-style-type: none"> <li>-No application of fertilizer within SMZs.</li> <li>-All other BMP guidelines for herbicides apply to fertilizer application.</li> </ul>
Kentucky	<ul style="list-style-type: none"> <li>-Use only pesticides approved by the Environmental Protection Agency for use in Kentucky.</li> <li>-Follow all pesticide label directions.</li> <li>-Application of some chemicals can require applicator certification and/or licensing.</li> </ul>	<ul style="list-style-type: none"> <li>-Use only amount of fertilizer necessary, and stay away from bodies of water or those areas immediately adjacent to them.</li> <li>-Avoid using fertilizers in SMZs</li> <li>-Avoid using fertilizers within 30 feet of any noticeable sinkhole opening.</li> </ul>
Louisiana	<ul style="list-style-type: none"> <li>-Follow label directions and applicable State and Federal laws in the storage, transportation, handling, and application of all chemicals.</li> <li>-Be aware of site characteristics, weather, and other factors that may be important for preventing water pollution.</li> <li>-No leakage permitted from equipment used for transporting, storing, mixing or applying chemicals.</li> <li>-Chemical mixing should only be done at application site.</li> <li>-Avoid mixing chemicals where spills may enter water bodies.</li> </ul>	N/A
Mississippi	<ul style="list-style-type: none"> <li>-Choose herbicide for intended uses and suitable for use on target species.</li> <li>-Use herbicides in accordance with label instructions.</li> <li>-Do not mix chemicals near springs, streams, and lakes.</li> <li>-Make sure weather is optimal for herbicide application.</li> <li>-Never apply herbicides directly to water (except when the chemical is approved for application over water).</li> <li>-Clean chemical application equipment away from streams and other water sources.</li> <li>-Dispose of excess herbicides and containers in accordance with label instructions.</li> </ul>	N/A
North Carolina	<ul style="list-style-type: none"> <li>-Applications must follow manufacturers' label instructions, EPA guidelines and the N.C. Pesticide Board of Regulations and Laws.</li> <li>-Pesticides designated as "Restricted Use" by EPA</li> </ul>	<ul style="list-style-type: none"> <li>-Fertilizer may not be broadcast closer than 25 feet to open water or perennial streams.</li> <li>-Fertilizer mixtures should take into account tree species and soil needs.</li> </ul>

	<p>require application by or under the supervision of applicators certified by the N.C. Department of Agriculture Pesticide Board.</p> <ul style="list-style-type: none"> <li>-Disposal of pesticide containers must be in accordance with directions contained on the label.</li> <li>-Transportation regulations for pesticides must be followed.</li> <li>-Pesticide containers or applicator equipment must never be cleaned in or near streams.</li> <li>-Pesticides should not be mixed near streams or water bodies.</li> <li>-Application equipment should be properly maintained and adjusted to prevent spillage and excessive application of toxic materials.</li> <li>-See BMP manual for aerial application and certain ground application rules.</li> </ul>	<p>-Application must be made according to the manufacturer's label instructions.</p>
Oklahoma	<ul style="list-style-type: none"> <li>-No significant leakage of chemicals should be permitted from equipment used for transportation, storage, mixing or application.</li> <li>-Mix chemicals and clean tanks only where possible spills would not enter a stream, lake or pond.</li> <li>-Avoid direct entry of chemicals into SMZs, flowing waters and stock ponds (applies to aerial and ground application).</li> <li>-Try not to exceed intended or allowable dosage.</li> <li>-Application should follow EPA container registration label guidelines.</li> <li>-Chemicals should be used only in accordance with State requirements for registration and regulation of sale or use of pesticides and for licensing of custom applicators and of aerial applicators.</li> <li>-Chemical containers should be removed from the forest and disposed of in a manner conforming to state regulations and label directions.</li> <li>-Equipment cleanup should take place where chemicals cannot enter water bodies.</li> </ul>	<p>-Same as for herbicides</p>
South Carolina	<ul style="list-style-type: none"> <li>-Follow pesticide label directions and applicable state and federal laws in the storage, transportation, handling, and application of all pesticides.</li> <li>-Restricted Use Pesticides (RUP) should only be applied under the supervision of a certified pesticide applicator.</li> <li>-Pesticide containers and/or excess pesticide should be disposed of according to state and federal regulations.</li> <li>-Follow guidelines for aerial and ground application.</li> <li>-All on-site pesticide handling should be conducted away from streams, ponds, and drainage areas.</li> <li>-Clean -up and/or contain all pesticide spills immediately and comply with state and federal</li> </ul>	<ul style="list-style-type: none"> <li>-Use fertilizer in prescribed amounts, only where site characteristics indicated that tree growth will be improved.</li> <li>-Protect water bodies with appropriate buffers to ensure fertilizer is not applied to them directly.</li> <li>-Properly dispose of fertilizer containers.</li> <li>-Avoid applying fertilizer prescribed for silvicultural purposes to water bodies, such as streams, ditches, or pools.</li> </ul>

	regulations concerning reporting spills of hazardous materials. -Avoid applying pesticides directly to water body unless specifically prescribed and approved for aquatic management needs. -Avoid broadcast applications of pesticides within primary SMZs.	
Tennessee	N/A	N/A
Texas	-Know site characteristics and chemical characteristics and other factors that might be helpful in minimizing pollution. -No visible leakage of chemicals should be permitted from equipment used for transporting, storing, mixing, or applying chemicals. -Mixing of chemicals should only be done at the application site and away from water bodies. -Clean up of tanks should only take place where spills will not enter water bodies. -Follow guidelines for aerial and ground application.	N/A
Virginia	N/A	N/A

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### Prescribed Burning

Fire may be used in to aid in site preparation in addition to the use of either mechanical or chemical methods (Georgia Forestry Commission 1999). Prescribed burning is used to get rid of unwanted vegetation, reduce logging residue, and also to reduce fuel on the forest floor (North Carolina Division of Forest Resources 1989, Georgia Forestry Commission 1999). Construction of fire lines is necessary when using fire on a forest site. Fire lines are basically strips of land cleared of all trees, vegetation, and other debris eliminating fuel and exposing the soil so that the fire will be suppressed and not spread beyond the desired area (Oklahoma Forestry Commission). Fire lines can be a source of sediment and may need to be water barred, especially if the lines are on steep slopes or have potential to flow into streams. Some of the guidelines for prescribed burning included by southern states are given in Table 11.

### **IV. BMP Implementation Rates**

The effectiveness of best management practices for forestry is dependent upon whether or not those engaging in forestry activities are implementing the BMPs. In order to determine whether or not best management practices are being implemented many states conduct surveys. The types of forestry practices monitored, the amount of resources states are willing to spend to conduct monitoring, and what methods they use to monitor practices are determined by several factors. These factors include financial resources available to the state, the amount and types of forests within the state, the types of forestry practices being used within the state, public and private interest in monitoring, and the availability of personnel (Ellefson et al. 2001). In comparison with the entire

United States, the South has the most states involved in monitoring practices affecting water quality and forested wetlands (Kilgore et.al 2001). According to the fourth survey of the National Association of State Foresters, the national rate for BMP implementation was 86 percent in 2000 (NASF 2001).

Most states that conduct surveys use a checklist to aid in determining whether or not landowners are using BMPs. The checklist usually outlines the forestry practices included in the BMP manual and certain criteria that must be met for each practice to be considered in compliance with BMP guidelines. For example, Alabama's BMP Monitoring Report form is divided into sections with the same headings as its BMP manual. There is a section for Streamside Management Zones, Stream Crossings, Forest Roads, Timber Harvesting, Reforestation/Stand Management, and Forested Wetland Management. Under each section are several criteria that a site inspector will be looking for to determine if each forestry practice is in compliance with BMP guidelines. While on site, the inspector can check whether or not each practice is utilizing BMPs and make note of deficiencies in BMP implementation (Alabama Forestry Commission 1993).

Many states report BMP implementation rate by forestry practice and by giving an overall percentage. Some states only report overall implementation rate. How frequently a state conducts BMP surveys and whether or not a state provides information by practice or publishes BMP survey results is dependent on available funding. For example, although Alabama monitors BMP implementation by practice, lack of funding keeps the state from giving percentages by practice or publishing its results (Albritton 2001). Most southern states do report implementation by practice and as an overall percentage.

Comparing forestry BMPs and BMP implementation rates between states is difficult. States are not required to follow the same format for creating forestry BMPs or for monitoring BMP implementation. According to a report by the BMP Monitoring Task Force appointed by the Southern Group of State Foresters, “Inconsistency among states with respect to statistical design, reproducibility, and general objectivity have been cited as areas of concern” (BMP Monitoring Task Force 1997).

The task force was assembled and given the assignment of creating recommendations for more consistent BMP monitoring for southern states. The recommendations made by the BMP Monitoring Task Force were published in 1997 in a paper titled, “Silviculture Best Management Practices Implementation Monitoring” (BMP Monitoring Task Force 1997). Although these recommendations have been made, only six of the southern states have conformed to the guidelines set forth by the task force (Prud’homme and Greis 2001). Until every southern state conforms to a common protocol for monitoring BMPs, comparison of BMP implementation rates will remain difficult. Table 12 includes individual practice and overall BMP implementation rates where available for the thirteen southern states.

**Table 12. Forest BMP Implementation Rates Overall and by Practice**

State	Year of Survey	Overall Compliance (% Compliance)	Forest Roads (% Compliance)	Timber Harvesting (% Compliance)	Site Preparation/ Reforestation (% Compliance)	Forest Fire Protection (% Compliance)	SMZs (% Compliance)	Stream Crossings (% Compliance)
Alabama	2000 <sup>(1)</sup>	98	-	-	-	-	-	-
Arkansas	1998/ 1999 <sup>(12)</sup>	80	75	77	79.5 <sup>(1)</sup> / -	-	81	-
Florida	1999 <sup>(7)</sup>	96	91	97	97 <sup>(b)</sup>	-	97	92
Georgia	1997/ 1998 <sup>(12)</sup>	78.7 <sup>(g)</sup>	-	87.3	97.6/96	61.5	80.9	58.8
Kentucky	2001 <sup>(3)(c)</sup>	81 <sup>(3)(c)</sup>						

Louisiana	1997 <sup>(10)</sup>	93/83 <sup>(e)</sup>	91.75	93	96	94	91	
Mississippi	1994 <sup>(9)</sup>	87	-	-	-	-	-	-
North Carolina	1996 <sup>(4)</sup>	95	92(a) (permanent roads only) 76.1(a) (Temporary roads and skid trails)	-	56.2(a)	-	96.6(a) (based on SMZ being free from logging and adequate ground cover)	-
Oklahoma	N/A	-	-	-	-	-	-	-
South Carolina	1997 <sup>(5)</sup>	84.7 (1991)	98.6	91.5	98/51	100	83.7	
Tennessee	1996 <sup>(11)</sup>	63	59.5	47.65	-	-	70	70.47
Texas (East)	June 3, 1998-August 31, 1999 <sup>(5)</sup>	88 (1997) <sup>(2)</sup>	94	89 <sup>(b)</sup>	96	-	86	-
Virginia	2000 <sup>(8)</sup>	97 <sup>(d)</sup>	73	-	33	-	70	-

- (a) Values (BMP and FPG) obtained by finding percentage of practices considered excellent and fair as a percentage of total practices observed; BMP and FPG percentages were averaged (Henson).
- (b) Average of clearcut and partial cut percentages.  
Sampling size, frequency, and criteria differ among states.
- (c) After the implementation of the Kentucky Forest Conservation Act approximately 1 year ago, ongoing inspections have been conducted (approximately 1600 sites inspected).
- (d) Based on efforts to implement BMPs not on effectiveness.
- (e) Percentage based on quantitative assessment; qualitative assessment shows 83% compliance.
- (f) Average of chemical and mechanical site preparation implementation rates.
- (g) Based on statewide BMP implementation compliance for all landowner classes and all physiographic regions.
- (h) Accounts for both site preparation and reforestation.

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## V. Conclusion

This summary of BMPs can provide general comparisons for different forestry practices and different states. Southern states have not adopted a uniform method for measuring or evaluating BMP implementation. Therefore, comparison of BMP implementation rates and the effectiveness of BMPs in protecting water quality remains difficult. Adopting a universal model for monitoring BMP compliance, as suggested by the BMP Monitoring Task Force of the Southern Group of State Foresters, would make comparison of implementation between states more meaningful.

This paper contains information as recent as spring 2002. Details for information covered in this paper are contained in the referenced BMP manuals and articles.

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