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NATIONAL COUNCIL FOR AIR AND STREAM IMPROVEMENT

# FORESTRY OPERATIONS AND WATER QUALITY IN THE NORTHEASTERN STATES: OVERVIEW OF IMPACTS AND ASSESSMENT OF STATE IMPLEMENTATION OF NONPOINT SOURCE PROGRAMS UNDER THE FEDERAL CLEAN WATER ACT

**TECHNICAL BULLETIN NO. 820**

**JANUARY 2001**

**by**

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## PRESIDENT'S NOTE

Forestry is a modest or insignificant source of water quality problems in the United States at regional and national scales compared to other economic activities. Nevertheless, forestry receives considerable attention in water quality laws and debates because forestry operations are ongoing activities in many watersheds that have high value for recreation and wildlife habitat.

Significant progress has been made over the past 25 years in efforts to minimize impacts of forestry operations on water quality. The National Council has participated in these efforts by supporting research to fill key information gaps, and by documenting the development and implementation of nonpoint source control programs for forestry.

This report reviews state and regional programs for controlling forestry nonpoint sources in the Northeastern United States. It completes a series of four regional reports that will be updated periodically in the future.

Collectively, the regional reviews show that all states with significant amounts of timber harvest activity have nonpoint source control programs for forestry. These programs are based on implementation of Best Management Practices that have been proven effective by extensive research. Many state programs perceive a need to strengthen their research and extension efforts, and to improve documentation of BMP implementation rates. However, funding to support improvements in forestry nonpoint programs is scarce because states are directing limited resources to controlling more significant sources of water quality problems such as agriculture and municipal wastewater treatment plants.

Ronald A. Yeske

January 2001

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## ABSTRACT

This report assesses silvicultural nonpoint source (NPS) pollution control programs for the twelve northeastern states (Pennsylvania, West Virginia, Maryland, Delaware, New York, New Jersey, Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and Maine). It relies on existing information, supplemented by interviews with state program managers and scientists. This report is current as of year-end 1997. Our principal findings are that:

1. In their state assessments ("319 reports") the states, while recognizing data limitations, generally rank silvicultural sources as modest or insignificant compared to other nonpoint sources. Several state assessments do not mention silvicultural sources of pollution at all.

2. Water quality monitoring, especially in headwater streams, is limited, so that the 319 reports have little field information to rely on. The low level of monitoring seems to reflect a shared impression that logging effects on water quality are currently minor, localized, and generally transitory. NPS monitoring efforts are being directed to more significant problems.

3. Important coldwater fisheries and spawning areas are found in headwater streams across this region. Even ephemeral streams may be important to the ecology of upstream waters, and they can provide channels for sediment to reach perennial streams.

4. Estimates of acres affected by logging and silvicultural activities were prepared in only a few states. Of the region's 80 million acres of commercial forest, at most only about 2% per year, or 1.6 million acres, are affected by almost 40,000 individual logging operations. Depending on the soils and logging methods used, anywhere from 10% to 40% of this acreage would actually be subject to significant disturbance of mineral soil or forest floor. The incidence of sedimentation may be more heavily affected by the attitudes and behaviors of landowners and loggers than by equipment, soil, slope, or hydrologic conditions.

5. State environmental and forestry agencies currently devote little staff and funding to enforcement and monitoring of BMPs, except in states where they are required to do so under recently passed Forest Practices Acts. Because they have changed over time and are often not readily identified, this report has not quantified state staff commitments.

6. Most states have a number of different laws that supplement Clean Water Act goals. Most often these are wetlands laws and erosion and sediment control laws of general application. Substate and local administration of rules affecting forest management is common in this region.

7. All states rely heavily on education and training, voluntary compliance, and citizen reporting of pollution or infractions of rules. Because of turnover among landowners and loggers, the job of education and training never ends.

8. Best Management Practices (BMPs) and guidebooks have been prepared by most of the states. These rely heavily on older USDA Forest Service publications. The latest research is not always reflected in the BMPs, some of which are under revision.

9. Only a few field surveys of compliance and effectiveness have been conducted in the region. They show that much has been accomplished since 1972. Occasional, localized occurrences of erosion and sedimentation occur. These surveys also demonstrate varying degrees of noncompliance with specified BMPs. It is not clear what a suitable standard would be for evaluating percentages of compliance with BMPs. Such percentages should be examined in the context of the maturity of a program and the significance of the remaining NPS problems. Room for improvement exists, and pressures are growing in some areas to achieve improved compliance.

10. The region is liberally endowed with long-term monitored watersheds which have provided valuable basic knowledge and baseline conditions, yet there is little ongoing field research on the actual long-term with/without effects of using Best Management Practices. Effectiveness of buffers is well established, and field studies support the effectiveness of most other practices.

11. Information on compliance and BMP effectiveness for site preparation and for fertilizer and pesticide runoff is rarely mentioned in available documents and is widely scattered in the technical literature. For this reason, and because of the localized use of these practices, they are not considered in this report.

12. Social science research on forestry BMPs and programs is meager. Clear, published documentation of costs, benefits, and alternatives is almost entirely lacking for this region, while research on the social correlates of BMP use in forestry is totally absent. Reliable, published, locally applicable information on the net cost of installing BMPs to loggers and landowners is nonexistent. There is essentially no ongoing field-based research evaluating the effectiveness of alternative program implementation, training, and enforcement methods. The forestry and the water communities should take advantage of the learning opportunities presented by the diversity of approaches in the northeast.

**KEYWORDS**

nonpoint source, Best Management Practice, forest practices, water quality, Pennsylvania, West Virginia, Maryland, Delaware, New York, New Jersey, Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, Maine

**RELATED NCASI PUBLICATIONS**

Technical Bulletin No. 710 (February 1996). *North central states nonpoint source program review*.

Technical Bulletin No. 706 (December 1995). *Western states nonpoint source program review*.

Technical Bulletin No. 686 (December 1994). *Southern regional review of state nonpoint source control programs and Best Management Practices for forest management operations*.

Technical Bulletin No. 672 (July 1994). *Forests as nonpoint sources of pollution, and effectiveness of Best Management Practices*.

Special Report No. 83-01 (January 1983). *Summary of silvicultural nonpoint source control programs - 1982*.

## CONTENTS

## TABLES

## FIGURES

# FORESTRY OPERATIONS AND WATER QUALITY IN THE NORTHEASTERN STATES: OVERVIEW OF IMPACTS AND ASSESSMENT OF STATE IMPLEMENTATION OF NONPOINT SOURCE PROGRAMS UNDER THE FEDERAL CLEAN WATER ACT

## 1.0 INTRODUCTION[1]

This report provides a region-wide overview on the nature of forestry-related impacts on streams for the Northeast United States. It then briefly reviews state-level programs aimed at managing those impacts through implementation of the Clean Water Act and other legislation. Finally, it supplies a tabular summary of those programs for easy reference. Overall project objectives are shown in Table 1.1.

The purpose of this report is not to supply a detailed inventory and comparison of the individual provisions of the Best Management Practices (BMPs) and regulations themselves. Elements of such comparisons can be found in Watson (1997) and Tetra Tech (1993). An earlier regional survey was summarized in Irland and Connors (1994a, 1994b). The report also does not evaluate state programs or compare them as to effectiveness.

This region, containing 20% of the nation's population, is a major net importer of wood-based products. It is also a significant producer of a wide variety of wood products. These industries remain significant to the region's rural economy. Wood producing industries have been a significant focus for state economic development programs, notably in Pennsylvania and West Virginia. The forests, and the streams and lakes that the forests sustain, are also a highly valued setting for hunting, fishing, boating, hiking, and a variety of other outdoor recreation activities that produce billions of dollars in economic activity each year (NFA 1994).

**Table 1.1.** Objectives for Regional Review

| | |
|---|---|
| 1. | Summarize available information about the scale of forest management effects on water quality and the relative importance of forestry and other nonpoint sources |
| 2. | Identify and describe state statutes, regulations, and programs for controlling nonpoint source pollution from forest management operations |
| 3. | Summarize studies of compliance with regulatory and/or non-regulatory nonpoint source control programs for forestry |
| 4. | Identify and describe educational/extension efforts to promote compliance with regulatory and/or non-regulatory nonpoint source control programs for forestry |
| 5. | Summarize studies of the effectiveness of regulatory and/or non-regulatory nonpoint source control programs for forestry |

Results in this report are based on reviews of literature, interviews with scientists and program managers, and personal professional experience. To obtain state-by-state information, officials in every state were interviewed and state documents were assembled. These officials reviewed

[1] Note on abbreviations: Throughout the text, Department of Environmental Management and Department of Environmental Protection are abbreviated DEM and DEP, respectively.

preliminary drafts for accuracy and completeness. Additional reviews were obtained from a number of experts.

## 2.0 LAND-USE PATTERNS

Coastal portions of this region have been settled and farmed for nearly 400 years. Some of these long-settled areas have gone through several cycles of forest clearing, development, and forest regrowth. Half of the region's farmland is in New York and Pennsylvania; half of its water area (lakes, ponds, reservoirs, etc.) lies in New York and Maine. Forests dominate the rural landscape here, accounting for 72% of the rural land, as shown in Table 2.1.

**Table 2.1.** Northeastern States: Generalized Land Uses

| Land Use | Million Acres | Percent of Rural Land |
|---|---|---|
| Rural cropland | 16.8 | 15.4 |
| Pasture | 8.5 | 7.9 |
| Forest | 78.1 | 72.2 |
| Minor uses | 4.9 | 4.5 |
| All rural | 108.2 | 100.0 |
| Developed (urban) | 11.2 | NA |
| Water | 5.6 | NA |
| Flood prone | 7.8 | NA |

Source: USDA Natural Resources Conservation Service.

The most heavily forested states are Maine and New Hampshire, while the least forested are Maryland and New Jersey (Table 2.2).

Cropland and pasture account for one-fourth of the region's rural land. The most heavily agricultural states are Delaware, Pennsylvania, Maryland, New York, and New Jersey, all of which have 20% or more of their rural land devoted to cropland and pasture. Towns, home sites, farmsteads, power lines, and similar uses occupy only 5% of the region's rural land.

Urban development accounts for about 11 million acres in the region, or about 9% of the total land area. The second Resources Conservation Act (RCA) Appraisal by the Soil Conservation Service forecast that developed land in the region will increase by 3.2 million acres from 1982 to 2030 (USDA SCS 1987).

Forest ownership is largely private (Figure 2.1). About two-thirds of the industry ownership is in Maine, while half of the public ownership is in New York and Pennsylvania. Farm ownership fell by more than half from 1952 to 1992, while industry, public, and other private ownerships increased.

**Table 2.2.** Northeastern Rural Land Uses by State and Subregion, 1992

| State | Rural Cropland | Pasture | Forest | Minor | Rural Total |
|---|---|---|---|---|---|
| Maine | 2 | 1 | 93 | 4 | 100 |
| New Hampshire | 3 | 2 | 90 | 5 | 100 |
| Vermont | 12 | 7 | 80 | 1 | 100 |
| Massachusetts | 8 | 5 | 79 | 9 | 100 |
| Connecticut | 10 | 5 | 79 | 6 | 100 |
| Rhode Island | 5 | 5 | 83 | 6 | 100 |
| SUBTOTAL NEW ENGLAND | 5 | 2 | 88 | 4 | 100 |
| New York | 21 | 11 | 64 | 4 | 100 |
| Pennsylvania | 23 | 10 | 63 | 5 | 100 |
| West Virginia | 7 | 12 | 78 | 3 | 100 |
| Maryland | 34 | 11 | 48 | 7 | 100 |
| Delaware | 50 | 3 | 35 | 13 | 100 |
| New Jersey | 22 | 5 | 60 | 13 | 100 |
| SUBTOTAL MID-ATLANTIC | 20 | 10 | 65 | 5 | 100 |
| ALL STATES | 15 | 8 | 72 | 5 | 100 |

Source: USDA Natural Resource Conservation Service.

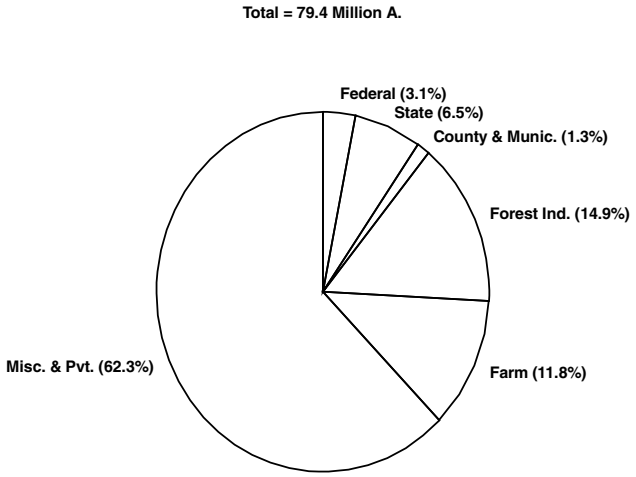


**Figure 2.1.** Ownership of Commercial Forestland, Twelve Northeastern States, 1992

## 3.0 REGIONAL FOREST, SOIL, AND HYDROLOGIC CONDITIONS

The northeastern states covered in this review include a wide diversity of climatic, soil, forest, and hydrologic conditions.

### 3.1 Forest Types and Conditions

Forest conditions across this region are highly diverse. This region is a transitional zone between the hardwood forests to the south and the true boreal forests of Canada. Forest composition has been strongly affected by past cutting and grazing, in some areas accompanied by wildfire or intentional burning. Large acreage consists of secondary stands growing on abandoned farmland. Significant areas are in early successional stages. Boundaries between distinctive forest regions are difficult to draw because changes are gradual and many species (white pine, hemlock) occur in patches and as minor associates across the region. Some formerly dominant species like white pine have been reduced to a fraction of their former importance, as in the drainages of the Delaware and Susquehanna Rivers.

Commercial forest acreage in the region increased from 73 million acres in 1952 to 80 million in 1992 (Table 3.1). According to USDA Forest Service estimates (Powell et al. 1993), the forests of this region have also seen a healthy increase in total annual wood growth since 1952. Total region-wide growth (in cubic feet) has increased, and exceeds removals. In 1991, the estimated growth-removals ratio was 1.43 for softwoods and 2.9 for hardwoods. Updated ecological units have recently been defined for the region, though they do not always correspond to generally used terminology for forest types (Figure 3.1).

**Table 3.1.** Forest Types, Northeastern United States, 1992 (unreserved only)

| Forest Type | Acres (1000) | Percent |
|---|---|---|
| White-Red-Jack Pine | 7,437 | 9.2 |
| Spruce-Fir | 10,203 | 12.7 |
| Loblolly-Shortleaf[1] | 1,538 | 1.9 |
| Oak-Pine | 2,220 | 2.8 |
| Oak-Hickory | 24,157 | 30.0 |
| Oak-Gum-Cypress | 329 | 0.4 |
| Elm-Ash-Cottonwood | 2,567 | 3.2 |
| Maple-Beech-Birch | 28,205 | 35.0 |
| Aspen-Birch | 3,195 | 4.0 |
| Other and Nonstocked | 693 | 0.9 |
| TOTAL | 80,544 | 100.0 |

[1] Mostly pitch pine.
Source: Powell et al. 1993, p. 26.

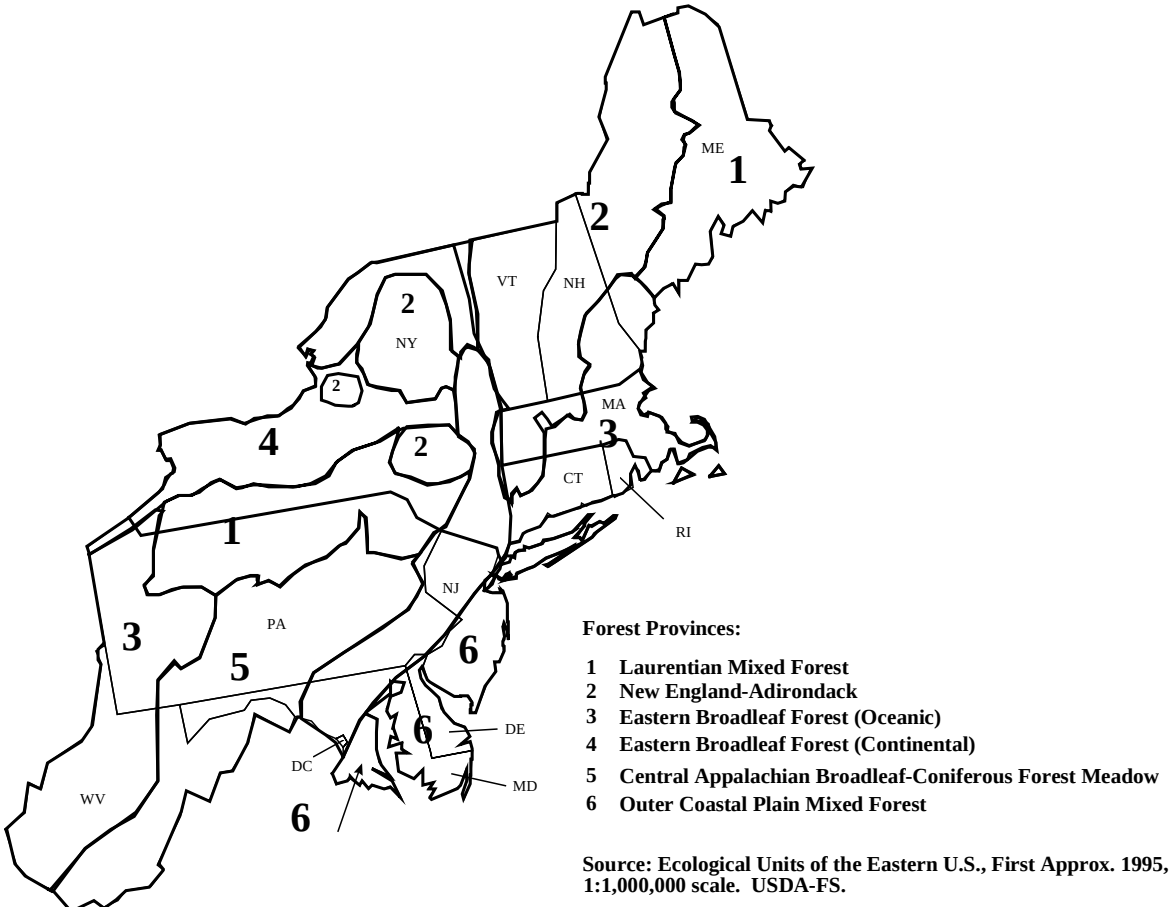


**Figure 3.1.** Ecological Units of the Eastern United States

In local areas, the planting of pines and some exotics has been important. White pine plantings have amounted to hundreds of thousands of acres over the years. In New York State, Norway spruce has been widely planted, and across the region, hybrid larches, Scots pine, and other species are seen. Locally, red pine is important, as in the southern tier of New York.

From the Adirondacks to eastern Maine lies a region consisting of a mix of sub-boreal and related types, often called the "spruce-fir region." Here, spruce-fir stands occur in subalpine situations and in lowland wet sites, often adjacent to streams. Spruce and fir are often important associates in "mixed wood" stands dominated by northern hardwoods. Across much of this area, fir composition has been reduced by the spruce budworm outbreak. The outbreak motivated large salvage clearcuts in the late 1970s and 1980s in northern Maine.

White pine is commonly associated with northern hardwoods as an emergent, and it forms extensive nearly pure stands in local areas of western Maine, New Hampshire, and upstate New York. It frequently mixes with oak stands in some areas.

A number of seral types are found. Aspen and birch are common post-fire types. Naturally seeded white pine often occupies drier old fields, whereas red cedar and gray birch are common on dry, overgrazed pastures in the Mid-Atlantic States.

A broad region of pine-hemlock-northern hardwoods occurs to the south and west of this area, as spruce-fir drops out of lowland situations and is confined to subalpine sites. Maple, beech, yellow birch, and hemlock typify this forest, though white pine is an important associate and occasionally forms pure stands. The valuable black cherry is locally important on the plateau of central and western New York and northwestern Pennsylvania.

Stretching from the southern half of Pennsylvania across to southern Maine, the oak-hickory type includes valuable species such as white and red oak. Forest condition and composition were affected by the loss of the American chestnut to the chestnut blight and later by repeated gypsy moth outbreaks. In southern Pennsylvania, West Virginia, and Maryland, trees in this type can reach impressive size, producing valuable sawtimber and veneer.

A distinctive pine-oak type typified by the pitch pine stretches from the sandy coastal plains of the Delmarva Peninsula to Cape Cod.

Across the region, acid to neutral bog types with a distinctive boreal appearance occur, ringed by spruce, cedar, tamarack, or Atlantic white cedar. Wet, poorly drained areas of perched water tables or riparian bottoms contain a mix of species that varies from north to south. These may include red alder, sweet birch, elm-ash-red maple stands, and others.

Because wet, poorly drained sites are common in this region, defining precisely what constitutes a wetland for regulatory purposes is technically difficult and politically contentious. Past classifications and estimates may be useful biologically, but cannot be considered authoritative in terms of policy. One estimate of wetlands area was used in the second RCA Appraisal. It holds that "palustrine" wetlands in this region cover about 7.6 million acres, or about 7% of the rural land. Estuarine, marine, riverine, and lacustrine wetlands not primarily covered by trees or shrubs are excluded from this definition (USDA SCS 1987, p. 267 for detail and definitions).

### 3.2 Water and Related Resource Values

The streams, ponds, and lakes of the region's forested areas represent an important resource providing many social values. Even ephemeral headwater streams can supply organic matter input to food chains and offer seasonal habitat for young fish and aquatic insects. Riparian forests along the headwater streams maintain cool water temperatures, supply organic matter, provide large woody debris, and shelter many kinds of wildlife. The cold water fisheries of the headwater areas are the basis for a valuable sport fishery. The region contains an estimated 230,000 miles of perennial and non-perennial streams (Table 3.2). The cumulative impacts of past mining, road building, timber cutting, farming, and other activities have damaged stream habitat in many areas. In such situations, there is increased sensitivity to any effects of current and future land management actions.

Progressing downstream and to larger lakes and ponds, the water uses become more varied, including municipal and industrial water supply, swimming and boating, and aesthetic uses. These uses of water can all be harmed by sediment reaching the water, from whatever source. The downstream fish habitats also differ, more commonly being important for warm water fish. So, the economic and social values associated with the water resources of northeastern forests are high. As access to upstream areas for anadromous fish is improved during the current process of hydrodam relicensing, the fishery habitat values of these waters will increase.

**Table 3.2.** Total Stream Miles, Northeastern States

| State | Total Stream Miles[1] |
|---|---|
| Maine | 31,672 |
| New Hampshire | 10,881 |
| Vermont | 5,264 |
| Massachusetts | 8,229 |
| Rhode Island | 1,106 |
| Connecticut | 5,830 |
| SUBTOTAL NEW ENGLAND | 62,982 |
| | |
| New York | 52,337 |
| New Jersey | 6,450 |
| Pennsylvania | 53,962 |
| Delaware | 3,158 |
| Maryland | 17,000 |
| West Virginia | 32,278 |
| SUBTOTAL MID-ATLANTIC | 165,185 |
| | |
| TOTAL NORTHEAST | 230,000 (approx.) |

[1] Perennial plus non-perennial.

Source: USEPA 1995a. *The quality of our nation's water: 1994*; and state summaries.

### 3.3 Logging Methods and Silvicultural Practices

Silvicultural practices and logging systems vary widely across the region. Cutting practices are influenced by the low log quality of many stands and the resulting low unit values of products removed; more than half of the volume removed in 1986 was pulpwood and fuelwood. Logging in this region typically relies on the rubber-tired skidder. On small woodlots, horses, oxen, and small equipment are still occasionally used. On the larger industrial ownerships and in plantations, various mechanized systems including large feller-forwarders, delimbers, and slashers are used. Useful reviews of the technical literature on logging and water quality include Vigon (1985); Omernik and Griffith (1991); Turcotte, Smith, and Federer (1991); Patric (1980); Patric, Evans, and Helvey (1984); Pierce (1980); Burns and Hewlett (1983); NCASI (1992); Hagenstein (1977); and Hornbeck et al. (1986). Abundant references are found in Satterlund and Adams (1992), MacGregor (1994), USEPA/NSF (1998), and Pierce et al. (1993).

In much of the region, partial cutting or high-grading is common, and much of the clearcutting seen along roadsides is actually land being cleared for farming or development. In particular areas, salvage of insect- or disease-damaged timber creates an urgency to harvest stands and may limit silvicultural choices. Examples include salvage clearcutting of gypsy moth-killed oak in the Mid-Atlantic States and southern New England, and large clearcuts for budworm salvage that occurred in Maine up until about 1985.

Intensive softwood silviculture is uncommon outside of industrial lands. Natural regeneration is commonly overabundant, and often of less desired species. Mechanical site preparation is rare; drainage and bedding are even less common. In some areas, herbicide treatments are used to control competing brush in natural or planted stands; this practice is concentrated in Maine at present (Table 3.3).

**Table 3.3.** Estimates of Annual Harvesting and Silvicultural Activities Examples from Northeastern States, 1980s

| | Acres | Percent of Forestland Annually[1] |
|---|---|---|
| Maine, 1990 | | |
| Partial cuts | 293,000 | 1.70 |
| Clearcuts[1] | 82,000 | 0.50 |
| Harvested | 375,000 | 2.20 |
| Maine, New Hampshire, Vermont, and New York | | |
| Total: Preharvest entries[2] | 90,000 | 1.33 |
| Maryland | 27,500 | 1.10 |

[1] Has declined significantly since 1988.
[2] Includes plant and seed, Timber Stand Improvement, site preparation (much of which is mechanical), and other noncommercial entries.
Sources: Maass 1989, Whipkey and Bennett 1989, Powell et al. 1993, Maine Forest Service 1991, Koehn and Grizzel 1995.

Estimates of the acreage affected by harvesting are sparse. As a working estimate, probably at most 2% of the region's 80 million forested acres are affected by logging each year, or 1.6 million acres. This is scattered in thousands of operations. Several reports by the Forest Inventory and Analysis Unit (FIA) of the USDA Forest Service have used FIA plot data to assess the extent of cutting disturbance between surveys in New England, Pennsylvania, and West Virginia (Gansner et al. 1990, Birch et al. 1992, Gansner et al. 1993). In these cases, the proportions of timberland cut during the survey intervals are shown in Table 3.4.

**Table 3.4.** Proportions of Timberland Cut during Surveys

| | Period | Percent of Area Cut | Annual Ave./Yr. |
|---|---|---|---|
| Pennsylvania | 1976-88 | 30 | 2.5 |
| West Virginia | 1979-89 | 24 | 2.4 |
| New England | 1970s-80s | 30 | 3.0 |

In each of these cases, most of the cutting consisted of light to moderate volume removals. For example, in West Virginia, over the years 1979 to 1989 only 17% of the acreage harvested experienced 80% or more of volume removal.

During logging, the forest floor and mineral soil are disturbed or rutted to varying degrees depending on type of equipment used, slopes, layout of operations, intensity of harvest, soil type,

weather, and other factors (e.g., McCormack 1984; Hornbeck, Martin, and Smith 1986; Martin 1988). With so many variables, it is difficult to translate an estimate of total acreage logged into an estimate of the area actually subject to different degrees of rutting, exposure, or forest floor disturbance. Further, comparing the various studies of soil disturbance is difficult due to differing methods of data presentation, definitions, and perceptions of what constitutes disturbance. This research found no current and comprehensive assessment of available information on this topic for this region. From 8% to 40% of the area logged actually experiences some level of disturbance or exposure of mineral soil, though the high percentage is uncommon. The FY 91 Monitoring and Evaluation Report for the Allegheny National Forest reports that disturbed areas occupy 14% of harvest areas (USDA FS 1992). In West Virginia from 1985 to 1988, evaluators estimated that 8% of the logged area had exposed mineral soil (Whipkey and Bennett 1989, p. 96), which is at the low end of the range. Using the 40% rate would place an extreme upper limit on actual disturbance of mineral soil at 640,000 acres per year. A lower limit might be 10%, or 160,000 acres per year. This is distributed over and interspersed with larger areas of undisturbed forest floor. The percentage of exposed area can be controlled by careful planning and supervision in most instances.

By way of comparison, the region contains roughly 18 million acres of cropland. According to the USDA, 11.1 million acres of farmland were harvested in the region in 1991. This compares to from 160,000 to 640,000 acres of actual soil disturbance through logging each year (see also Nonpoint Source Task Force 1985, p. 5). Thus, farming involves 18 to 70 times as much annual soil disturbance as logging. Drawing this comparison is only meant to compare the activities as to area affected. Plainly, row cropping and logging differ in their hydrologic impacts in many ways.

### 3.4 Landforms and Soil Conditions

Soil conditions across the region are highly variable (Figure 3.2). They range from acid or alkaline bog and wetland types to subalpine peats, and from deeper residual soils in lowlands to shallow, fragile soils on mountain peaks. The region's soils include deep residual soils that developed on unglaciated, limestone-rich parent materials in the southerly portion of the region; extensive acid outwash plains in upstate New York and New England; local areas of alluvial bottomlands; and acid and loamy to clayey soils from the Adirondacks to northern Maine which are often shallow to bedrock or have dense, impermeable layers. In less disturbed areas and in higher elevations, deep organic layers develop under softwood stands.

Land use history has influenced these soils. Roughly 17 million acres of former crop and pasture land has "gone back" to forest during this century. In the long-settled coastal areas, past farming and erosion have eliminated surface soil horizons altogether in local areas. Elsewhere, millions of acres of former farm and pasture lands bear a combination of earmarks of their past uses. In the dairying areas that cover much of the region, woodland grazing has reduced soil porosity, reduced organic layers, injured regeneration, and damaged riparian areas and streambanks (see Patric and Helvey 1986 for a valuable review; and Irland 1995 for details for Maine).

In parts of Pennsylvania and West Virginia, extensive areas have been disturbed by coal strip mining and by gob piles from underground mining. Widespread efforts have been made to employ forest trees to stabilize and restore these lands. Borrow pits for highway construction and sand and gravel pits occasionally present similar needs. Due to steep slopes and low growth rates, future wood crops should probably not be anticipated on most of these lands. These disturbed soil conditions present differing levels of vulnerability to erosion and concern for impacts on water resources. In some situations the risks are slight, and in others, especially where slopes are steep, risks are high, at least in certain seasons.

Forest soils in this region have varying levels of ability to recover from disturbance based on slope, soil textures, thickness of organic layers, degree of disturbance, and rates of revegetation (e.g., Reisinger, Pope, and Hammond 1992). Generally, the moist climate and infrequency of summer drought promotes rapid revegetation. In colder areas winter freezing and thawing can slowly eliminate some ruts and soil compaction.

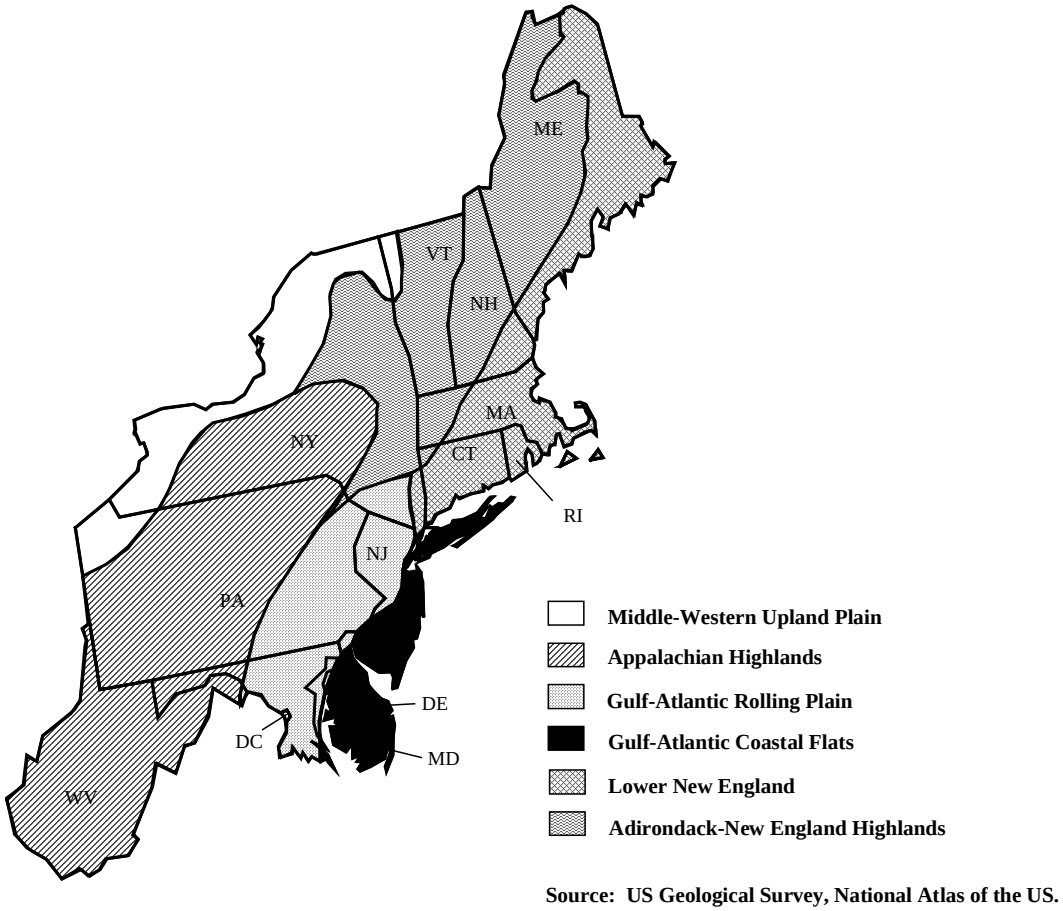


**Figure 3.2.** Landforms in the Northeastern Region

## 3.5 Climate and Hydrologic Conditions

Climate variations are significant across this region (Table 3.5). Normal mean daily temperatures do not seem widely different from north to south, but the mean number of days below 32 degrees indicates the differing length of the cold season. The mean number of days with precipitation exceeding 0.01 inch is lowest at Baltimore and rises to the north and west. Mean annual precipitation declines to the north and inland.

This region generally experiences precipitation well distributed throughout the year (Figures 4 to 7). A significant hydrologic fact is the occurrence of soil freezing and snow. These are rare in the southerly states, and extend five months or so in northern Maine. Snowfall exceeds 128 inches per year in the Adirondacks and White Mountains, and exceeds 96 inches per year in northern Maine and much of New York.

**Table 3.5.** Climate Data, Northeastern Cities

| City | Normal Mean Daily Temp.[1] | Mean Days Precip. >.01"[2] | Mean Annual Precip. | Mean Annual Snowfall[3] |
|---|---|---|---|---|
| Charleston, WV | 55.0 | 151.0 | 42.53 | 32.6 |
| Baltimore, MD | 55.1 | 113.0 | 40.76 | 20.6 |
| Portland, ME | 45.0 | 129.0 | 44.34 | 70.6 |
| Albany, NY | 47.3 | 135.0 | 36.17 | 63.7 |
| Pittsburgh, PA | 50.3 | 153.0 | 36.85 | 43.4 |
| Burlington, VT | 44.1 | 154.0 | 34.47 | 77.5 |
| Presque Isle, ME | | 160.4 | 36.59 | |

[1] 1961 to 1990.
[2] Period of records through 1994.
[3] Snow and ice pellets, period of record to 1994.
Source: USGPO 1991, Statistical Abstract of the U.S. 1991; National Weather Service, pers. comm.

Across the highlands of Pennsylvania, annual snowfall averages 30 inches or more, and it exceeds 64 inches in parts of West Virginia's mountains. Winter weather produces soil saturation in West Virginia and the southerly portions of the region. To the north, winter weather produces spring and fall "mud seasons" during which skidding, log hauling, and road construction are difficult or may be halted altogether. The pace of logging operations can be determined by the dates when soils freeze enough to support logging equipment in the fall, and when roads thaw during spring "break-up." On some soils, operations conducted before fall freeze-up and during spring break-up will create a higher risk of erosion and sedimentation. On the other hand, operations conducted on snow over frozen ground may protect the soil and regeneration from any noticeable disturbance.

In this region, gentle rainfall from frontal storms occurs during the growing season, as well as occasional high-intensity rainfall from summer thundershowers. Over much of the region, rainfall can exceed two inches on the maximum day; in the coastal area and in the White Mountains and the Catskills, the extremes can exceed four inches per day. These extremes, however, are infrequent. Additionally, perhaps once every ten years the region experiences torrential downpours from storms associated with hurricanes; these storms can produce intense rainfall and local flooding at great distances from the coast. In the extraordinary New England storm event of October 1996, for example, 12 inches of rain fell in parts of the White Mountains in less than two days; the maximum was 20 inches in south coastal Maine. With this tendency to experience extreme rainfall events, road construction, culvert design, and other soil disturbing activities must accommodate the potential for extreme as well as average weather (for background, see relevant sections of Hornbeck and Leak 1992).

There is evidence that both the total quantity of precipitation in the northeastern United States, and the frequency of high intensity storms (rainfall >2") has increased (Karl and Knight 1997). In fact, much of the increased total precipitation volume is occurring in the form of more intense summertime storms. This trend, almost invisible in any brief period, could affect the relevance of judgments about erosion potential or BMP effectiveness made on the basis of past storm intensities and frequency.

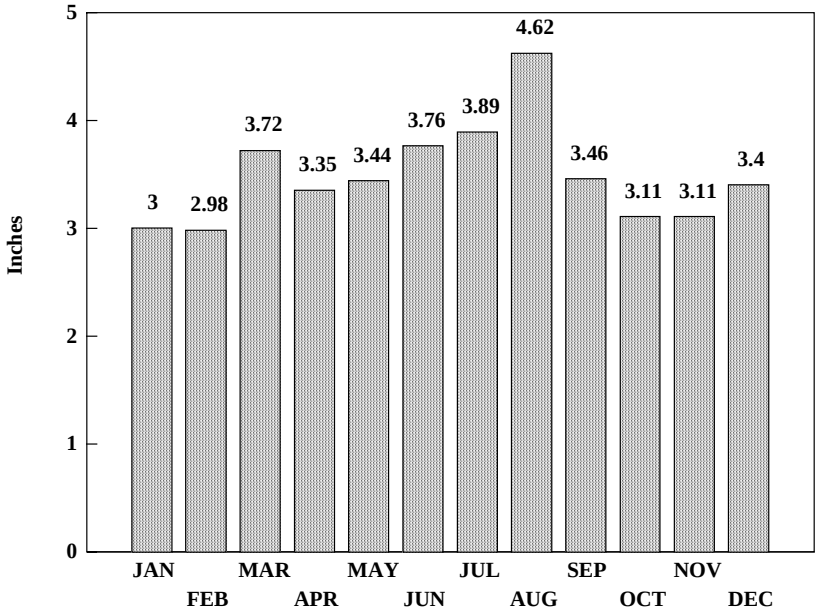


**Figure 3.3.** Baltimore Monthly Precipitation

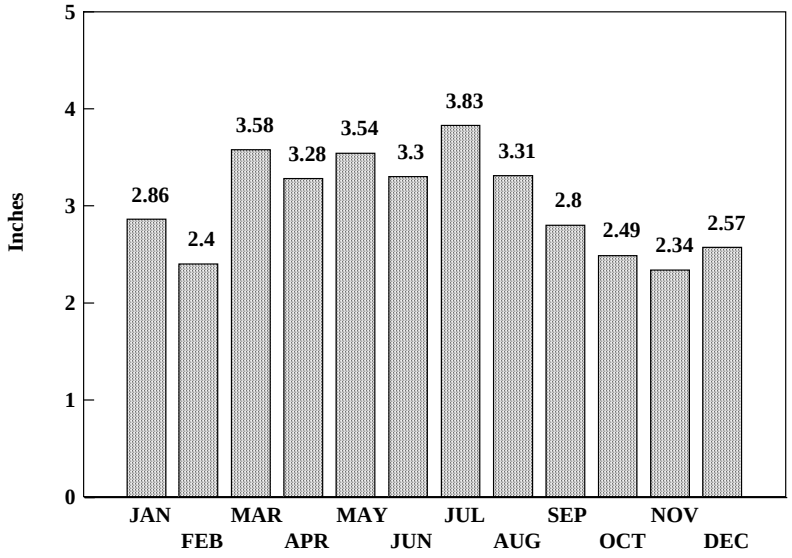


**Figure 3.4.** Pittsburgh Monthly Precipitation

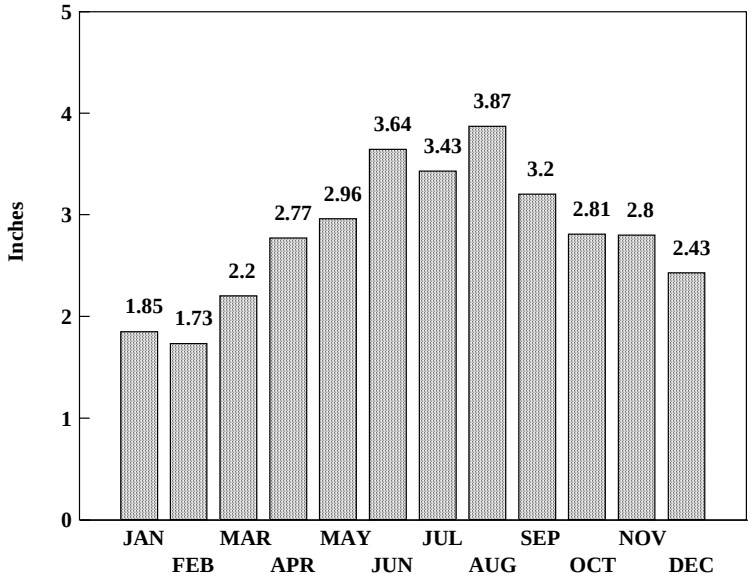


**Figure 3.5.** Burlington Monthly Precipitation

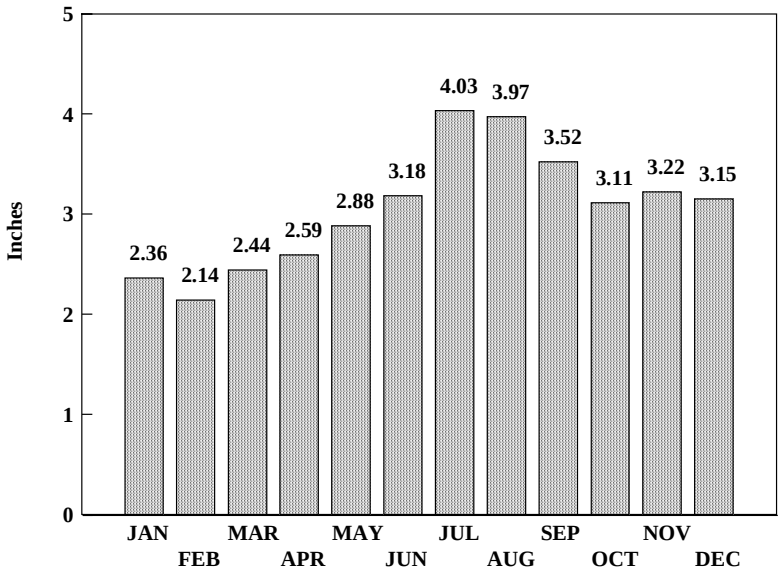


**Figure 3.6.** Presque Isle Monthly Precipitation

### 3.6 Erosion from Northeastern Forestland: Overview

Except for records at the Fernow and Hubbard Brook watersheds, long-term background data on sediment loads and turbidity from unmanaged forests are not widely available. For the unmanaged Fernow Watershed, Kochenderfer, Helvey, and Wendel (1987) documented annual sediment yield of 31 lb per acre per year for a 96-acre watershed unlogged for 80 years. For the New England region, Martin and Hornbeck (1994, p. 17) suggested that undisturbed forests would yield about 30 to 40 lb per acre per year of sediment. These estimates do not account for occasional large increases in sediment yields caused by wildfires or other disturbances.

In this region, when erosion and sedimentation from forestry operations occurs, it is normally associated with road building and stream crossings. Using poorly designed skid trails or logging steep slopes in careless ways can also produce erosion and resulting sedimentation.

In overall perspective, estimates by the Soil Conservation Service's National Resources Inventory (NRI) show that forested lands produce very low sediment yields compared to other rural land uses (Table 3.6). Cropland sediment yields exceed those in the forest by 10 to 30 times (Figure 3.7). Because of the predominance of forestland, however, aggregate sediment production from forests as a proportion of total sediment reaching waterways looms larger than the per-acre comparisons would suggest. Even so, forests are considered to be a minor contributor to total sediment loads reaching waterways. The NRI analysis is substantiated by the assessments provided in the state "319" reports. In those reports, many states noted that forestry activities are not seen as a significant contributor to stream sediment loads (Table 5.2). However, several states noted that limited monitoring and information hinders a full and accurate assessment.

In the SCS's 1982 National Resource Inventory, it was estimated that 1.8 million acres of the region's forestland (about 2%) was eroding at a rate exceeding its T value, or maximum tolerable limit (USDA SCS 1987, p. 238). This estimate was derived by applying the Universal Soil Loss Equation (USLE) to generalized data, and provides only a very generalized depiction. The bulk of this acreage was in West Virginia and Pennsylvania, where it is probably associated with mining. The other large occurrence was in Maine, where extensive clearcuts for spruce budworm salvage had recently been conducted. NCASI has identified concerns about using the USLE for forested lands; the Modified Universal Soil Loss Equation (MUSLE) is probably more appropriate (NCASI 1979; Dissmeyer and Foster 1980).

**Table 3.6.** Sediment Yields, Northeastern States, 1987, by Type of Land Use
(tons per acre per year)

| State | Rural Cropland | Pasture | Forest | Minor | Average All Rural Land |
|---|---|---|---|---|---|
| Maine | 1.6 | 0.1 | 0.0 | 0.2 | 0.1 |
| New Hampshire | 1.6 | 1.0 | 0.1 | 0.2 | 0.2 |
| Vermont | 1.3 | 0.3 | 0.3 | 0.2 | 0.4 |
| Massachusetts | 2.7 | 0.2 | 0.1 | 0.1 | 0.3 |
| Connecticut | 3.3 | 0.2 | 0.1 | 1.0 | 0.5 |
| Rhode Island | 2.6 | 0.2 | 0.0 | 3.0 | 0.4 |
| SUBTOTAL NEW ENGLAND | 2.9 | 0.2 | 0.1 | 1.4 | 0.4 |
| New York | 2.7 | 0.4 | 0.1 | 6.1 | 1.0 |
| Pennsylvania | 5.6 | 1.6 | 0.5 | 34.6 | 3.6 |
| West Virginia | 2.6 | 6.7 | 2.3 | 18.9 | 3.3 |
| Maryland | 5.1 | 1.1 | 0.3 | 0.3 | 2.1 |
| Delaware | 2.1 | 0.9 | 0.1 | 0.3 | 1.1 |
| New Jersey | 6.4 | 0.6 | 0.1 | 0.6 | 1.5 |
| SUBTOTAL MID-ATLANTIC | 4.5 | 0.9 | 0.2 | 0.4 | 1.6 |

Source: USDA SCS 1989, Table 6.

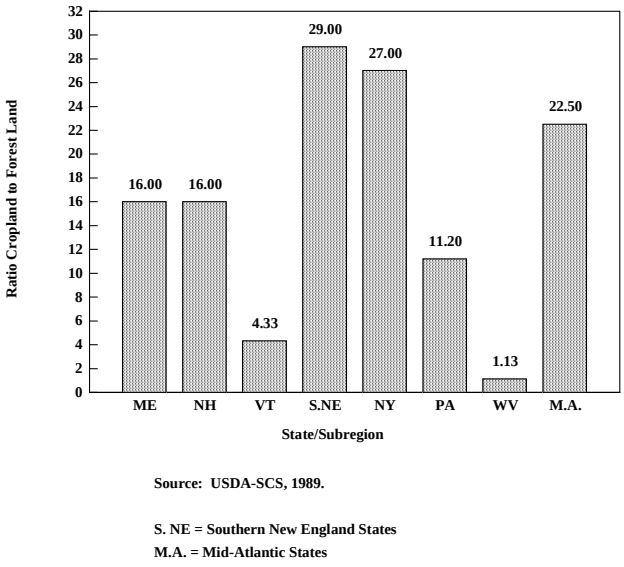


**Figure 3.7.** Comparative Sediment Yields per Acre

### 3.7 Implications

Forests of the northeast are extremely diverse in structure and composition, level of management intensity, and vulnerability to erosion. The aggregate area of soil annually disturbed in logging is a small fraction of that annually disturbed in agriculture, and average per-acre erosion rates in forested regions are lower. Climatic conditions also vary widely. But the headwater streams, lakes, and ponds of the region supply important resource values. The high elevation forested areas receive higher volumes of precipitation than do lowland areas, and are more prone to erosion because of their steeper topography.

A strong case can be made for protecting water resources in managed forests through the use of high standards of care in logging, road and bridge construction and maintenance, and other forest management activities, especially where erosion hazards are high and where high-value water resources are at risk.

## 4.0 STATE PROGRAM SUMMARIES

This section contains state-by-state summaries of forestry nonpoint source (NPS) program activities. The focus is on efforts undertaken specifically to implement Clean Water Act (CWA) requirements related to silvicultural activities. It is widely recognized that managing nonpoint sources of pollution is an emerging priority for the nation's water quality protection effort (US CG 1990, 1992a, 1992b; USEPA 1998). Section 6 provides a summary of state program information by program element. This assessment relies on existing information and interviews. Information has been assembled in several categories: NPS assessments, NPS program organization and implementation strategies, program activities and accomplishments, and results from research, compliance, and effectiveness studies. Draft summaries were reviewed by representatives of all states, leading to useful improvements in accuracy and completeness.

One distinctive trait of this region is its tradition of strong local or municipal government involvement, especially in the more northern states. In some areas, towns are active in administering state and local forest practice regulations. The existence of local regulation of forest activities is noted in applicable state summaries, but no additional effort was made to document the nature or effects of local controls, as state NPS programs do not rely on this level of regulation. For a useful regional overview, see Hickman and Martus (1991), Cubbage (1991), and Cubbage and Siegel (1988).

In addition, the region contains several substate regional entities with forest practice responsibilities (Figure 4.1). Profiles of these are included in the related state reports. The state reports are given in alphabetical order.

States in this region have implemented forestry BMP programs largely to satisfy federal mandates under the Clean Water Act (PL.92-500, as amended). States have additional legal powers for protecting water quality, which generally dovetail with federal requirements. The states are the legal holders of navigable waters in trust for the public. For historic reasons, in most Eastern states navigable means "capable of floating a log." Additionally, health and welfare powers provide a basis for protecting the quality of downstream waters. Finally, private riparian owners have rights to the undiminished quality of flows past their property. These rights have been important in providing the legal foundation for water quality management programs. Under the water quality laws, landowners hold prime responsibility for compliance. Depending on circumstances and state regulations, logging operators, road builders, or other contractors may also be held responsible for violations. To illustrate the diversity of BMPs, a list from Maine will indicate the number of issues

that can arise on a given logging job (Table 4.1). One item that many would add to this listing would be "preharvest planning" as a distinctive practice for each individual operating area.

EPA's 1992 Report to Congress provides a summary overview of the status of the national NPS program, on a regional basis and by state (US EPA 1992). Although now out of date, this report is the most current national summary of NPS program activities available. General updating, with examples, can be found in the 1994 and 1996 water quality reports to Congress.

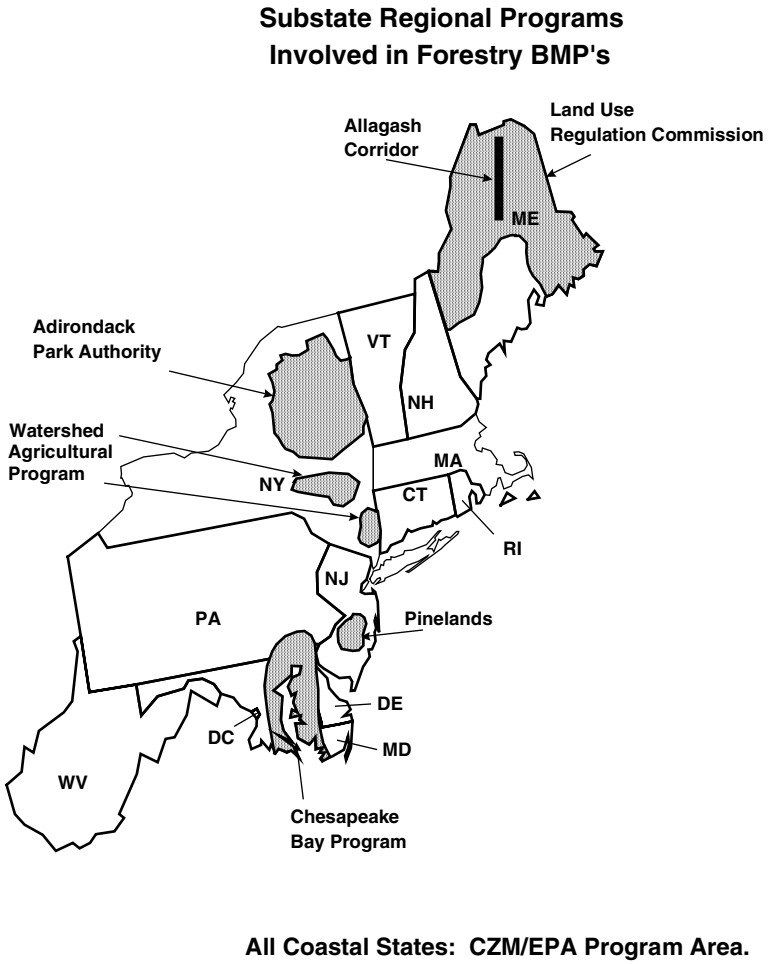


**Figure 4.1.** Substate Regional Programs Involved in Forestry BMPs

**Table 4.1.** BMPs Reviewed in Maine Compliance Study

| Type | BMP No. | Recommended BMP |
|---|---|---|
| Haul roads | 1 | Minimize number of roads and road lengths |
| | 2 | Use existing roads unless they aggravate erosion |
| | 3 | Fit road to topography, and avoid wet areas and toes of banks and slopes |
| | 4 | Avoid inappropriate use of winter roads |
| | 5 | Avoid flat road sections that are difficult to drain |
| | 6 | Keep road grade within 3 to 5%, maximum 10% slope for short distances |
| | 7 | Keep roads 75 ft from streams, 250 ft from lakes, great ponds |
| | 8 | Avoid sharp curves (minimum 50-ft turn radius) |
| | 9 | Road banks no steeper than 2:1 |
| | 10 | Drainage ditches adequate to divert water away from the road |
| | 11 | Drainage ditches stabilized |
| | 12 | Cross drainage culverts spaced appropriately |
| | 13 | Culvert cross sectional area adequate for water flow (usually minimum 15 in.) |
| | 14 | On slopes >10% install culverts at a 30-degree angle down slope |
| | 15 | Culverts installed at least 1 ft below surface, and slopes 5 in/10 ft |
| | 16 | Culvert shoulders stabilized with stone |
| | 17 | Culverts maintained adequately or removed |
| | 18 | Outflow length adequate, empties onto stone, slash, or logs, and water prevented from reentering road |
| | 19 | Inlet extends into side ditch, intercepting all water |
| | 20 | Roads crowned where possible |
| | 21 | Broad-based drainage dips used/spaced properly |
| | 22 | Broad-based drainage dips discharge area protected using stone, grass, sod, heavy litter, slash, logs |
| | 23 | Cut/fill banks or other exposed areas outside of road bed within 75 ft of water revegetated or otherwise stabilized |
| | 24 | Road grades broken at stream crossings and surface water dispersed to filter strips |
| Stream crossings | 25 | Minimize stream crossings |
| | 26 | Culverts/bridges used as needed to cross streams |
| | 27 | Cross sectional area of culvert/bridge adequate; maintained or put to bed |
| | 28 | Culvert/bridge location and placement adequate |
| | 29 | Streams crossed at right angle with reasonably level approaches (50 ft both sides) |
| | 30 | Watercourses not used as skid trails |
| | 31 | Watercourses forded only on hard bottom and hard banks |
| | 32 | Culvert extends beyond any fill |
| | 33 | Log crossings do not impede flow or the passage of fish |

(Continued on next page. See note at end of table.)

**Table 4.1.** Continued

| Type | BMP No. | Recommended BMP |
|---|---|---|
| Skid trail | 34 | Skidding is across the slope where possible, long slopes >10% (esp. downhill), sharp bends avoided |
| | 35 | Stream crossings minimized |
| | 36 | Skid trail distances minimized to <1/2 mile if possible |
| | 37 | Sensitive sites harvested when ground frozen (poorly drained), or dry (steep) |
| | 38 | Skid trails avoid wet areas and tops and toes of banks and slopes |
| | 39 | Water turnouts or water bars used as needed to divert surface runoff |
| | 40 | Skid humps spaced appropriately and slash used to divert water on steep slopes (>10%) |
| Put to bed | 41 | Cross drainage culverts removed |
| | 42 | Adequate spacing of water bars |
| | 43 | Face of water bar extends 12 in above road surface and 12 in below road surface |
| | 44 | Water bars installed at a 30-degree angle downslope |
| | 45 | Water bar outlet extends, prevents reentry into ditch |
| | 46 | Rocks, slash, or logs disperse and filter water at outlet |
| | 47 | Steep skid trail sections stabilized with vegetation or brush if needed |
| Log yards/ landings | 48 | Landings located on gentle slopes with good drainage |
| | 49 | Water diverted out of landings to filter strips |
| | 50 | Water prevented from running into low, poorly drained landings |
| | 51 | Landing at acceptable distance from protected area (stream, pond, lake, steep slope, wetland) |
| | 52 | No evidence of discarded oil or other fluids |
| | 53 | No evidence of litter |
| | 54 | Soil stabilized after landing closeout (revegetated if necessary) |
| Streamside zones | 55 | Adequate shade retained over perennial streams |
| | 56 | Slash kept out of stream channel (drains over 300 acres?) |
| | 57 | Sediment barriers and revegetation effectively used to prevent sediment from entering stream where there is potential despite planning |
| | 58 | Filter strips used where needed |
| | 59 | Filter strip width adequate for slope gradient |
| | 60 | Filter strip is adequately vegetated (40%) and the duff is undisturbed |
| | 61 | No soil disturbance within filter strip |
| | 62 | Drainage ditches terminate in filter strips, not surface waters |

Source: Briggs, Kimball, and Cormier 1996, p. 28ff.

## 4.1 Connecticut

### 4.1.1 *Assessment*

Silviculture is rated low in relative importance as a nonpoint source of pollution. "Forest management and logging activities in Connecticut are generally not of the magnitude and type that result in major surface water impacts. Due to local water resource concerns and other factors, numerous towns have adopted regulations through their zoning authority to regulate logging activities" (O'Hayre 1980). An estimated 600 logging operations occur in Connecticut each year.

### 4.1.2 *Forest Practice Regulation*

A new Connecticut Forest Practices Act (Public Act 91-335) was passed in 1991. It requires the certification of persons "engaged in commercial forest practices," and authorizes the adoption of forest practices regulations. The law also provides a mechanism to assure consistency with municipal ordinances. Under the law, "forest practitioners" (foresters and loggers) must be certified by the state (CT LJ 1995, Sec. 23-65h-l). At present, 117 foresters, 273 supervising harvesters, and 100 harvesters have been certified.

Connecticut's Inland Wetlands and Water Courses Act (CGS Sect. 22a, 36-45) applies to timber harvesting activities that result in alterations of a wetland. A permit is required from the local municipal wetlands commission. The law prohibits clearcutting in wetlands.

Municipal Zoning Authority allows localities to regulate certain forest practices.

Forest practices regulations are under development, and are expected to be issued in 1998.

### 4.1.3 *Nonpoint Source Program*

NPS programs are implemented through the DEP Bureaus and Divisions and federal, regional (RC&D), and municipal activities. The Forestry Division provides technical assistance to loggers and foresters, and will administer the certification program for forest practitioners as the regulations pursuant to the Forest Practices Act are approved.

Published BMPs are available as *A Practical Guide for Protecting Water Quality while Harvesting Forest Products*. These were prepared by the Connecticut RC&D Forestry Committee (1990) and are available from the Forestry Unit. An updated silvicultural BMP handbook is planned. Only about a dozen violations per year are referred to the DEP Water Bureau.

### 4.1.4 *Substate Programs*

None.

### 4.1.5 *Instruction and Education*

A Study Guide for the certification program has been developed.

### 4.1.6 *Compliance*

No recent compliance or effectiveness studies are available, but see items cited in Irland (1985) and O'Hayre (1980).

### 4.1.7 *Effectiveness*

See previous section.

### 4.1.8 *Current Research*

Extensive watershed modeling is underway at the University of Connecticut, emphasizing nutrient transport and hydrology. Timber harvest effects have not been a direct concern of this work, which has focused largely on transport of pollutants.

### 4.1.9 *Current Policy Initiatives*

Forest Licensing.

### 4.1.10 *References*

*Connecticut Legal Journal* (CT LJ). 1995. DEP-certification of forest practitioners. Forest Practices Act, Title 23. Hartford: Department of Environmental Protection; Forestry Unit. February 21, 1995. 4 pp. + fact sheet.

Connecticut RC&D Forestry Committee. 1990. *A practical guide for protecting water quality while harvesting forest products*.

Irland, L.C. 1985. Logging and water quality: State regulation in New England. *Journal of Soil and Water Conservation*. 40(1):98-101.

O'Hayre, A.P. 1980. *Survey and analysis of silvicultural activities in relation to nonpoint source pollution in the State of Connecticut*. Connecticut Department of Environmental Protection; Forestry Unit.

### 4.1.11 *Contacts*

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### 4.1.12 *Websites with Local Information*

http://www.lib.uconn.edu/CANR/ces/index.html

## 4.2 Delaware

### 4.2.1 *Assessment*

The state NPS Coordinator reports that "silviculture is an approved NPS category," because it is recognized that under certain conditions forest harvesting can cause localized problems. The 1996 Assessment reports on a survey (p. I-4) showing that 80% of the state's nontidal streams have degraded habitat. The causes of degraded habitat vary across the state. Multiple nonpoint sources were often involved. This situation shows the importance of protecting riparian habitat, which is a prime focus of the state's sediment and erosion control effort. Approximately 150 logging jobs occur in Delaware annually.

### 4.2.2 *Forest Practice Regulation*

In 1990, the Stormwater and Sediment Law for Delaware (Delaware Code, Ch. 40, Title 7) was modified and forestry activities became regulated. A new law passed in 1994 placed responsibility for forestry matters with the State Forester in the Delaware Department of Agriculture (DDA) Forest Service (ch. 29, subch. VI). Staff foresters provide assistance to landowners and operators with timber harvesting activities, including the processing of permit forms. The permit form has recently been simplified.

### 4.2.3 *Nonpoint Source Program*

A forestry element of the state's NPS Program (DNREC 1996, part V) is based on the use of the BMP booklet (DDA 1995) as an educational tool. Although the 1994 law formally defines a "regulatory" program, emphasis is placed on education rather than enforcement. The enforcement mechanism is very time-consuming, and is rarely used. As a result, the administration of the law resembles a voluntary program.

### 4.2.4 *Substate Programs*

See Chesapeake Bay Program.

### 4.2.5 *Instruction and Education*

Training for landowners and loggers is being initiated through Extension, Soil Conservation Districts, and other groups. The state is teaming up with the Maryland Loggers Program to provide a structured training course for loggers. Many area loggers work in Maryland, Virginia, and Delaware, freely crossing state lines.

### 4.2.6 *Compliance*

In 1997, 137 permits were issued and 200 inspections were performed. On 130 sites there were no water quality problems. Seventeen had potential water quality problems and one had a severe problem. With the intensity of inspections, formal compliance surveys have been considered unnecessary.

### 4.2.7 *Effectiveness*

No research known.

### 4.2.8 *Current Research*

None known.

#### 4.2.9 *Current Policy Initiatives*

A new MOU on administration of the Erosion and Sedimentation Law is being developed with the DNR, covering situations where forestland is being converted for development.

#### 4.2.10 *References*

Delaware Department of Agriculture (DDA), Forest Service. 1995. *Delaware's forestry BMP manual*. Dover. 78 pp.

———. 1996 *Delaware's forestry BMP field manual*. Dover. 71 pp.

Delaware Department of Natural Resources and Environmental Control (DNREC). 1996. *State of Delaware, 1996 Watershed Assessment Report 305(b)*. Dover. April 1996. var pg.

#### 4.2.11 *Contacts*

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fax: 302-697-6287

#### 4.2.12 *Websites with Local Information*

http://www.dnrec.state.de.us

### 4.3 Maine

#### 4.3.1 *Assessment*

According to Maine's NPS assessment, silvicultural sources are considered by state agencies to be a minor to moderate problem statewide, but silvicultural issues are considered moderate to high priority water quality problems in some watersheds. There are no lakes, coastal waters, groundwaters, or wetlands where silvicultural sources are documented as the cause of water quality non-attainment. The 1996 assessment has not been published fully, but is available on computer disk (Maine DEP 1996).

As the DEP notes in its 1996 assessment (p. 33), "The lack of data on nonpoint source impacts to streams and coastal water bodies has significantly affected the focus of the nonpoint program. ...Few streams and estuaries have been evaluated for these impacts. Until recently, staff resources were not available to address these data deficiencies." In its summary tables on the statewide situation (Tables 3-2.3, 3-2.4), there is no category for identified forestry impacts at all. Presumably such impacts as do occur are either occurring in remote areas not sampled, or are obscured by other factors.

During the 1990s, Maine has seen an extraordinary amount of research and policy debate about forestry impacts on water quality and on BMPs. This has included one administrative field survey (Stafford, Leathers, and Briggs 1996, p. 12), one major research project (Briggs, Kimball, and Cormier 1996; Briggs, Cormier, and Kimball 1998; Cormier 1996), the deliberations of a Council on Sustainable Forestry (1996), and no less than three extensive literature reviews (Kahl 1996; Stafford, Leathers, and Briggs 1996; Moring and Finlayson 1996). An earlier field study was LURC (1979); see also Spicer and Mansius (1997).

***The Briggs Compliance Study***

In cooperation with state and federal agencies, Briggs, Kimball, Cormier, and co-workers conducted an extensive field survey of silvicultural BMP compliance, making visual observations on sediment movement to assess effectiveness where applicable. BMPs were studied in six general groups: haul roads, stream crossings, skid trails, putting sites to bed, log yards and landings, and stream management zones. A total of 60 specific practices were covered. This study is the most thorough and detailed assessment of BMP compliance in the region to date. Its results were presented in considerable detail in the publications cited previously. The reports generated by this study provide considerable discussion of the many methodological difficulties of this kind of field evaluation. They also illustrate the extreme difficulty of extracting meaningful summaries from such complex information.

Though a detailed water monitoring study was not conducted, the authors did examine adjacent water bodies for evidence of siltation. They were able to conclude that, except for a few isolated instances, "BMP compliance substantially reduces sedimentation" (Briggs, Kimball, and Cormier 1996, p. 22).

To develop a compact summary of the Briggs results, the FORAT (Forestry Advisory Team) committee members converted the compliance results to letter "grades," as shown in Table 4.2.

**Table 4.2.** FORAT Grades for BMP Compliance in Maine, Based on Briggs, Kimball, and Cormier 1996 Results

| Grade | Point Range Compliance Rate | Percent of Sites Receiving Grade, across all 60 BMPs evaluated |
|---|---|---|
| A | 90 to 100% | 22 |
| B | 80 to 90% | 12 |
| C | 70 to 80% | 13 |
| D | 60 to 70% | 15 |
| F | below 60% | 38 |

Less than 50% of sites examined were graded passing ('C' or better). It is often remarked that the degree of compliance varies inversely with the cost of the practice, but this is not supported in this instance. For example, stream management zones had no instances of 'A' grades, but haul roads had 28% rated 'A.' Sample sizes for many individual cells in this analysis were small, however, because not all harvested sites required every BMP. How costs affect BMP compliance probably depends on who is doing the planning. Landowners, for example, would consider revenues lost in riparian buffers, while loggers likely would not.

It would be fair to say that there have been differences of views as to how these "grades" and the original data are to be interpreted. This effort to give grades does raise an important point; however, it is not at all straightforward to determine what an adequate level of BMP compliance is. There are differences in interpreting BMPs, and there may be difficulties in applying the guidelines to specific sites.

One of the important study results was that landowners (of the sampled sites) displayed a low level of awareness of the BMP requirements (Briggs, Kimball, and Cormier 1996, p. 23). This suggests a high level of delegating the application of BMPs to loggers and consultants on behalf of the landowners.

***The Literature Reviews***

The three literature reviews discussed research reports from Maine and other regions that were considered relevant for particular points. A detailed recital of all of their conclusions would be excessively lengthy, but a selective summary runs risks as well. General conclusions supported by all of them are that BMPs are effective in minimizing sedimentation into streams when properly installed, and that changes in nutrient inputs and streamflows caused by logging operations are generally temporary. There is a great deal, however, that is not known about how logging, with or without BMPs, affects a number of chemical constituents that were not examined in the various instrumented watershed studies. There is also agreement that improvements in the provisions and the communication of the BMPs are needed. Kahl (1966) pointed to, among other things, the importance of tightening protection for smaller streams, reducing fording of streams, and conducting cutting at times of least likelihood for rutting and stream damage (e.g., on frozen ground). Kahl also raised questions concerning possible effects of ions such as aluminum that have not yet received widespread study in fieldwork and monitoring. Aluminum has been monitored at Weymouth Point (J. McLaughlin, pers. comm.).

In reviewing literature specifically focused on Maine salmon steams, Moring and Finlayson (1996, p. 57) noted "We have no strong evidence that logging activities are significantly affecting Atlantic salmon and their habitat, unless BMPs are not followed and buffer strips are not employed." Throughout their review they emphasize the importance of protective buffer strips, even though they recognize that such strips may not fully eliminate all sediment movement to streams.

Taken together, the three reviews provide a ready access point to a great deal of relevant information.

***The Council on Sustainable Forest Management***

This Council was appointed by Governor Angus King in early 1996 to develop a number of forest policies supporting long-term sustainable forest management. As the Council was doing its work, the state became embroiled in a lengthy debate over an initiative to ban clearcutting and to gain consensus for an alternative proposal called the Compact for Maine's Forests. As a result, adoption and implementation of specific proposals by the Council is uncertain.

In its report (Maine CSFM 1996), the Council emphasized the importance of improving protection of small headwater streams and offered tighter standards, including new coverage for unmapped streams. The state's current regulations provide for a maximum removal rate in streamside zones of 40% of the basal area; the Council noted that this rule could permit the progressive elimination of streamside shade over a few decades. It also highlighted the problem of low BMP compliance for certain practices.

### 4.3.2 *Forest Practice Regulation*

Forest practices in Maine are regulated to protect water quality and other resource values under regulations adopted by the Land Use Regulation Commission (LURC) (12MRSA, Ch. 206-A); Shoreland Zoning Act (38MRSA, Ch. 3, Sect. 435); Natural Resource Protection Act (38MRSA, Ch. 3, Sect. 480-A); and the Maine Forest Practices Act (12MRSA, Ch. 805, Sect. 8867). A detailed comparative review is provided by Connors, Murdoch, and Field (1992). A comparison of differences and conflicts was made in Maclean (1994).

Oversight of BMP implementation in Maine is complicated by the different regulatory regimes for the unorganized and organized townships (see discussion of Land Use Regulation Commission). Statewide, the Maine Forest Service (MFS) Fire Control and Forest Policy and Management Divisions are responsible for the Forest Practices Act enforcement. Under the FPA, the MFS receives about 8000 notifications per year. No actual tabulation from the database is made. Roughly 100 violations of various provisions are detected each year. The MFS (1992) has developed a field handbook for BMPs.

### 4.3.3 *Nonpoint Source Program*

The state's goal is to develop a broad-based program for reducing nonpoint source pollutants that incorporates BMP development, training, water quality monitoring, and enforcement. The strategy is designed to employ interagency agreements and cooperative programs with appropriate state agencies and other entities. The Maine Forest Service is the lead agency in developing silvicultural BMPs and related information and education efforts.

The state has impaneled a Forest Resource Advisory Team, called FORAT, to provide ongoing advice and discussion of water quality protection issues (Maine DOC 1995). The committee has broad representation from agencies and forestry groups. The staff responsibility for this committee has been shifted to the Department of Conservation (DOC), which has a water quality specialist on its staff. FORAT assisted in the Briggs survey and devoted considerable time to analyzing the results. The committee recommended that steps be taken to bring overall BMP compliance rates to 80% by the year 2010, and to conduct future studies at five-year intervals. They suggested that research is needed to explore why compliance rates are currently so low.

BMPs have been developed and published as *Erosion and Sediment Control Handbook for Maine Timber Harvesting Operations Best Management Practices* (MFS 1994). Copies are available from the Maine Forest Service. This BMP handbook is a revision and update of existing practices incorporated in related laws and regulations. The publication exists as guidelines, but BMPs are also established as part of existing regulations. A related publication by LURC (1995) applies within their jurisdiction.

About 60% of the harvests are inspected by a force of some 70 rangers and foresters each year. In these onsite visits, a number of points are noted, including whether notification has been made; size of clearcuts and "separation zones;" regeneration status on past clearcuts; and if relevant, theft and trespass. Rangers now use GPS systems to map areas involved. Aerial surveillance is routinely used to aid in detecting failures to notify and to locate clearcuts. For water quality violations, investigation is on the basis of complaints or problems discovered in the course of other work. Suspected violations of the water quality laws are referred to the DEP for enforcement action in the organized towns. In the unorganized towns, rangers refer suspected violations of LURC rules to that agency.

Roughly 50 water quality complaints occur in a typical year. Field visits by MFS or DEP staff are termed "interventions." The first priorities are compliance and remediation. Formal enforcement

action is reserved for uncooperative or chronic violators. For enforcement action to be effective legally, discharge must be proven, which can be difficult in an after-the-fact situation. Only a few cases ever reach the stage of going to court in an average year. Experience has shown that judges vary in their responsiveness to the state's viewpoint in these instances. Administrative settlement agreements can emerge from enforcement actions; these may be filed at county courthouses.

The MFS describes the process as follows:

> The FPA enforcement program utilizes a tiered approach which carries an investigation from the simple to the complex, which we feel makes best use of the 8 foresters and 70 rangers available, and their respective levels of training. To put it into forestry terms, rangers do the work of technicians and foresters that of licensed professionals. FPA enforcement carries a very high priority, and foresters are expected to spend 50% of their time on it. Rangers spend a somewhat smaller percentage of their time on FPA, but there are many more of them. Rangers deal with notification issues and make initial investigations of standard issues. The ranger brings the forester into the standards investigation at the point where he or she thinks there might be a violation, usually at a very early stage. At that point the licensed forester reviews the case, makes a field reconnaissance, and either determines that there is no violation or decides that a cruise is needed to make that decision. If the latter, he or she consults with the Enforcement Coordinator, and under his guidance they proceed with cruise design, planning, and implementation. The fieldwork for the cruise is carried out by rangers under the supervision of the forester. The forester then evaluates the data, which is used to document whether a violation exists or not. If a violation is present, the case is presented to the Enforcement Coordinator, who is responsible for working out a settlement agreement. If that fails, the Enforcement Coordinator turns the case over to the Attorney General and asks that he or she proceed with litigation. (see Figure 4.2) (R.E. Morse, pers. comm., Nov. 9, 1997)

In late 1997, the Department of the Interior authorized Maine to proceed with a complex Atlantic Salmon Conservation Plan (Maine Atlantic Salmon Task Force 1997) in lieu of endangered species designation for naturally reproducing salmon in coastal Maine streams. The Plan provides an extremely detailed portrait of existing agency plans and activities. It states that at present forestry activities are not considered a threat to salmon populations, but that a range of efforts will be undertaken to improve compliance with forestry BMPs.

### 4.3.4 *Substate Programs*

#### *Maine Land Use Regulation Commission*

In 1971, the Maine legislature created the Land Use Regulation Commission (LURC) to serve as a planning and regulatory body for Maine's unorganized territories (LURC 1997). This is an area of 10.4 million acres, which lacks local governments with such powers. Land ownership in this region is diverse, including more than a dozen large corporate and family ownerships and many hundreds of smaller individual ownerships and farms. Only 4400 households lived in this vast area in 1990, mostly in the small communities around its edges (LURC 1997; Irland 1996).

The LURC has created a system of land use zoning for its jurisdiction which leaves 80% of the land area in Management Districts, providing for traditional forest and related land uses. Because of the complexity of its mandate, the agency has working relationships with other agencies such as the

Departments of Environmental Protection and Inland Fisheries and Wildlife, and the Maine Forest Service.Regulatory concerns of the agency include protecting the quality of 11,000 miles of rivers and streams, retaining the wildness of identified "remote ponds," and ensuring that haul roads are

built to prescribed standards. Landowners must obtain permits from LURC if they seek a variance from agency management guidelines. Also, the Maine Forest Service administers the Forest Practices Act within the jurisdiction.

During the 1980s there occurred a major wave of wildland subdividing and development that brought new concern for the adequacy of LURC regulations. Partly for this reason, the agency's 1997 Revised Comprehensive Plan did not devote substantial attention to water quality issues. Conversations with responsible officials at LURC and DEP indicate a sense that they perceive that the problem is generally under control in the region, and is significantly improved from the situation 15 or 20 years ago. Managing for water quality is facilitated by the fact that the agencies only need to deal with a limited number of owners, contractors, and logging operators. Though the region is remote, springtime overflights provide a low-cost method of detecting water quality violations.

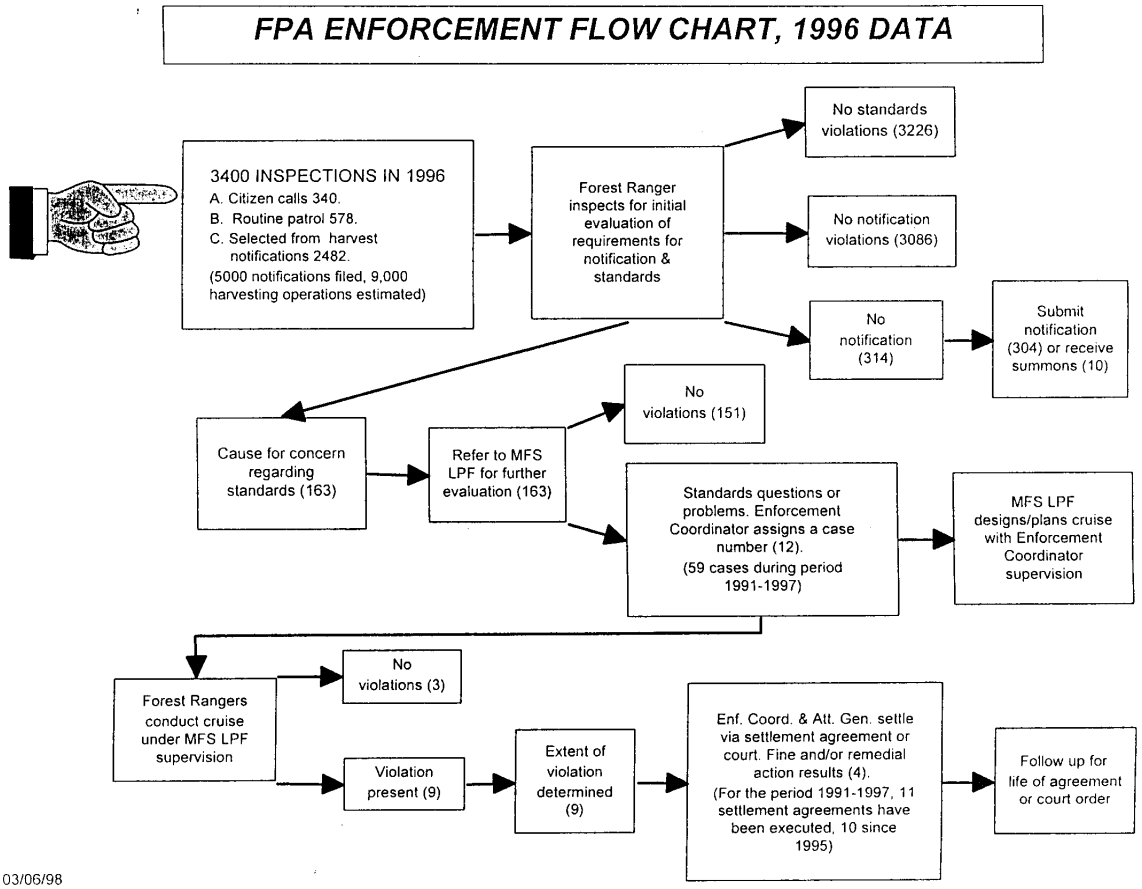


**Figure 4.2.** FPA Enforcement Flow Chart, 1996 Data

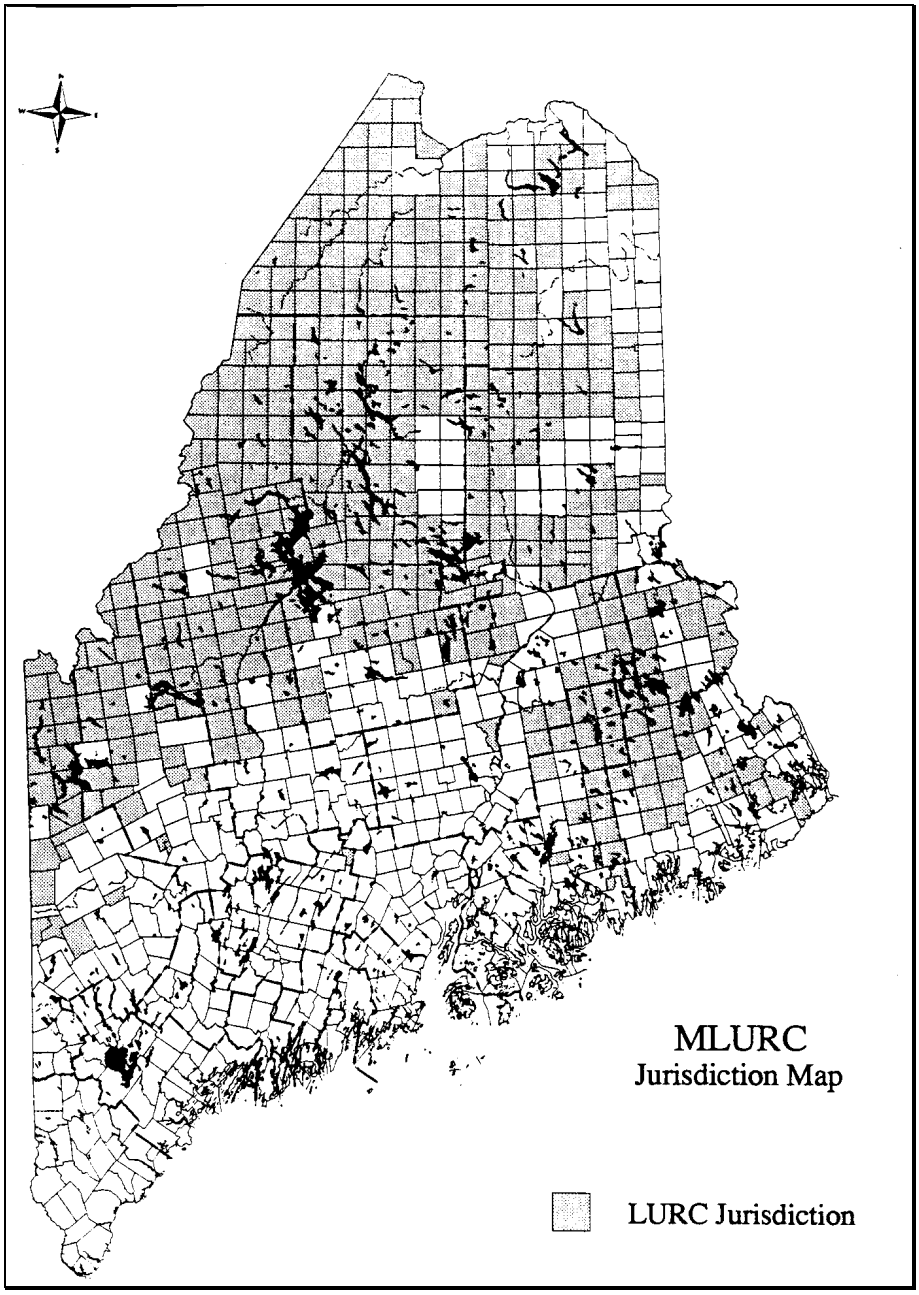


**Figure 4.3.** Maine Land Use Regulation Commission Jurisdiction Map

LURC has its own set of regulations providing for protection of water quality in its jurisdiction, and has prepared its own BMP summary in both English and French. In the 1995 draft of the Comprehensive Land Use Plan, the agency noted continued frustration over the lack of practical water quality monitoring methods. As issues for future concern, the agency noted impacts of recreation on water quality; management effects on site and habitat productivity; and "the effects of forest practices on wildlife habitats, steep slopes, and high mountain areas" (LURC 1995 draft Comprehensive Land Use Plan).

***Shoreland Zoning***

Under the state's land use laws, towns must designate shoreland zones within which cutting limitations apply. Towns handle permits within these zones.

### 4.3.5 *Instruction and Education*

A focused Instruction and Education program has been developed in cooperation with the Extension Service, Conservation Districts, Small Woodland Owners Association of Maine (SWOAM), and the DOC.

The Certified Logging Professional Program is an important program element. Published BMP guidelines and a forthcoming illustrated manual are incorporated into the environmental law section of this industry-sponsored educational program for professional loggers. To date, approximately 1500 loggers have graduated from the program.

In the Lyman Forest Demonstration Project, a system of logging roads was installed using proper water crossing and erosion control techniques as a demonstration project for loggers, foresters, and landowners. The project was carried out over three workshops. Cost data are available, but the effectiveness of the practices is not being evaluated. At the University Forest in Orono, a demonstration area for BMPs has been installed.

### 4.3.6 *Compliance*

In the early 1990s, a yearlong program was undertaken to assess the level of compliance with BMPs within the LURC jurisdiction, and to provide BMP training. Thirty-five active logging operations were reviewed during routine compliance inspections. The data have been compiled and submitted to DEP. An informed source at LURC reports that the level of compliance with their forest practices regulations was lower than expected, and that loggers were generally unaware of the new BMPs. In 1995, a major assessment of compliance was conducted (see below).

### 4.3.7 *Effectiveness*

See discussions of Briggs work in previous section.

### 4.3.8 *Current Research*

Research continues on the Weymouth Point and East Bear Brook watershed studies, and work is underway on harvesting in wetlands. Work continues on stream habitat classification; clearcutting, landscape features, and riparian management; and a cooperative program on BMP effectiveness with International Paper Company and Trout Unlimited.

### 4.3.9 *Current Policy Initiatives*

In its 1998 session, the Legislature is considering a number of forestry bills that were held pending resolution of the debate over the Compact. Included are bills relating to licensing and regulation of

loggers, forest practices, and studies of forest conditions and policies. These bills will undoubtedly include points related to water quality.

One of the bills that was carried over (LD 1430) established a committee to review the desirability of establishing a logger licensing program. The committee reported to the Commissioner of Professional and Financial Regulation in January 1998, suggesting that a licensing program is not warranted at this time. The report observed, however:

> The Committee believes that environmental laws are adequate but enforcement and education are lacking. More consistent enforcement of existing laws is needed, as are measures to promote greater use of BMPs. (LLTRC, p. 3)

They recommended that Maine adopt Vermont's approach to BMPs, under which the use of BMPs protects a landowner from penalties in the event of a discharge to state waters, though remedial action must be taken.

In January 1998, the DEP sent a report to the Legislature on the broad range of NPS concerns from existing sources (Maine DEP 1998). The report listed 14 "ideas" for improvements, including a unified set of BMPs, strengthened SMZs, better water quality monitoring, and a user-friendly BMP Manual (Maine DEP 1998, p. 18-19).

The 1998 legislative session mandated that the MFS and DEP prepare a report recommending statewide standards for BMPs to protect water quality. In July, the state's FORAT Committee held a daylong working conference on conservation buffers. The Legislature also passed a non-binding resolution endorsing the state's SFI program, but requesting greater use of public advisors and third-party auditing (see Sec. 6.3 in this report and Maine Forest Products Council 1998).

The Atlantic Salmon Restoration Plan will continue to be controversial. In a June 1, 1998, decision, United States Magistrate Janice Stewart ordered that the NMFS reconsider its decision not to list the coho salmon in Oregon because of the voluntary nature of Oregon's protection plan. That ruling is likely to prompt a court challenge to Maine's plan.

#### 4.3.10 *References*

Briggs, R.D., Cormier, J., and Kimball, A.J. 1998. Compliance with forestry BMPs in Maine. *Northern Journal of Applied Forestry*. 15(2):57-68.

Briggs, R.D., Kimball, A.J., and Cormier, J. 1996. *Assessing compliance with BMPs on harvested sites in Maine, final report*. Maine Agricultural Experiment Station Miscellaneous Report 400. 35 pp.

Connors, J., Murdoch, C., and Field, D. 1992. *Guide to forestry regulations in Maine*. Orono: University of Maine; Margaret Chase Smith Center. Technical Paper 07-01-92. 82 pp + app.

Cormier, J. 1996. *Review and discussion of forestry BMPs*. Augusta: Maine Department of Environmental Protection. 28 pp.

Irland, L.C. 1995. *Land use and water quality in Maine: a historical perspective*. Unpublished overheads for Maine Water Quality Conference. 24 pp.

———. 1996. *Land, timber and recreation in Maine's Northwoods*. Orono: Maine Agricultural and Forestry Experiment Station, Miscellaneous Publication 730. 81 pp.

Kahl, S. 1996. *A review of the effects of forest practices on water quality in Maine*. University of Maine Water Research Institute. Report to Maine Department of Environmental Protection; Bureau of Water Quality Control. 52 pp., w/cover letter dated Oct. 16, 1996.

Land Use Regulation Commission (LURC). 1979. *A survey of erosion and sedimentation problems associated with logging in Maine*. Augusta: Land Use Regulation Commission; Maine Department of Conservation. 56 pp.

———. 1995. *Erosion control on logging jobs*. Augusta: Maine Department of Conservation. Preliminary review. March. 34 pp.

———. 1997. *Revised comprehensive land use plan*. March 27. 169 pp. + app.

Logger Licensing Technical Review Committee (LLTRC). 1998. *Making the current laws work: report of the LLTRC*. Augusta: Maine Forest Service; Department of Conservation.. 30 pp. + app.

Maclean, C.A. 1994. *An analysis of inconsistencies in environmental protections standards pertaining to forest management activities in Maine*. Unpublished MS thesis. 150 pp.

Maine Atlantic Salmon Task Force. 1997. *Atlantic Salmon Conservation Plan for seven Maine rivers*. Augusta. var pg. Web at http://www.state.me.us/governor/a-plus.htm.

Maine Council on Sustainable Forest Management (Maine CSFM). 1996. *Sustaining Maine's forests: criteria, goals, and benchmarks for sustainable forest management*. Augusta: Maine Department of Conservation. 54 pp.

Maine Department of Conservation (Maine DOC). 1995. *Background and mission statement: forestry advisory team (FORAT)*. Processed. December 18. 2 pp.

———. 1997. *FAQs about the logger licensing technical review committee*. Augusta: October 1997. 4 pp. processed.

Maine Department of Environmental Protection (Maine DEP). 1996. *1996 assessment*. Available on disk.

———. 1998. *NPS pollution: existing sources*. Report to the 118th Legislature, Joint Standing Committee on Natural Resources. Augusta. January 30. 31 pp.

Maine Forest Products Council. 1998. *Maine's sustainable forestry initiative*. Augusta. 11 pp.

Maine Forest Service (MFS). 1992. *BMP's, field handbook*. Augusta: Maine Forest Service. 36 pp.

———. 1994. Erosion and sediment control handbook for Maine timber harvesting operations best management practices. Augusta: Maine Forest Service.

Moring, J.R., and Finlayson, K. 1996. *Relationships between land use activities and Atlantic salmon (Salmo solar) habitats: a literature review*. Maine Cooperative Fish & Wildlife Research Unit; University of Maine. Report to National Council of the Paper Industry for Air and Stream Improvement, Inc. (NCASI). 86 pp.

Spicer, D., and Mansius, D. 1977. *MFS-BMP survey results*. Augusta: Department of Conservation. June. 4 pp.

Stafford, C., Leathers, M., and Briggs, R. 1996. *Forestry-related nonpoint source pollution in Maine: a literature review*. Maine Agricultural Experiment Station Miscellaneous Report 399. 18 pp.

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#### 4.3.12 *Websites with Local Information*

http://www.state.me.us/doc/mfshome.htm

### 4.4 Maryland

#### 4.4.1 *Assessment*

The Maryland 1996 Assessment Report does not tabulate forestry and silvicultural sources of water quality problems in the state (MD DNR 1996). An estimated 2000 logging operations occur in Maryland annually.

#### 4.4.2 *Forest Practice Regulation*

***Timber Harvest Regulation***

Plans to harvest timber from three or more acres of land devoted to the growth of forest products are subject to review and approval under Maryland law (MAC Sec. 5-608[c]). Furthermore, all loggers and sawmills directing the work of loggers are required to be licensed (MAC, Natural Resources, Sec. 5-608[d]). Regulated cutting activities are subject to specified conservation requirements, including provisions for regeneration and seed tree retention. Observers have noted that Maryland "may have the most complex regulatory environment in the East" (Hawks et al. 1993, p. 53).

***Erosion and Sediment Control***

Any land use, including timber harvesting, that disturbs more than 5000 square feet of land area (roads, landings, skid trails) requires an erosion and sediment control plan (MAC, Environment, Sec. 4-101 to 4-109). This includes virtually all logging operations. To assist loggers in meeting this requirement, the Maryland Water Management Administration and Maryland Forest, Park, and Wildlife Service have developed a Standard Plan for Forest Harvest Operations. This plan contains the general sediment control requirements that will enable a harvest to use the Standard Plan, and is available at any Soil Conservation District Office. The Maryland Department of the Environment (MDE) and the Maryland Forest Service have also prepared *Soil Erosion and Sediment Control Guidelines for Forest Harvest Operations in Maryland* to assist foresters, consultants, and loggers in developing a plan. These guidelines are available from the Maryland Department of the

Environment. In addition, a temporary stream crossing permit is required when crossing a perennial stream with a drainage area of 400 acres or more, or a designated trout stream (Perdue 1990). The 400-acre drainage area rule is being revised to zero—the rules will then apply to all perennial streams. Permits are filed with the MDE. The intensity of field inspections varies by county. Severe compliance problems are rare, but when they occur, field officers can stop work. Fines and imprisonment are authorized, but are rarely imposed.

***Chesapeake Bay Critical Area Program***

The Chesapeake Bay Critical Area Program (MAC, Natural Resources, Section 8-1801 et seq.) establishes a 1000 foot wide critical area around the bay and major tributaries, as well as other designated areas. Land use activities within this area are controlled, including timber harvesting (Parker 1990). A forest harvesting plan must be approved by a district forestry board, and a number of harvesting conditions must be met. There can be no harvesting in buffer zones within 50 feet of the Bay, and only selective cutting in the next 50 feet (except loblolly pine or yellow poplar, which may be clearcut). A forest management plan prepared by a registered forester is required for any cutting of one acre or more in the critical area, and the operation must be conducted in accordance with an approved erosion and sedimentation control plan. An extensive effort to establish new forested buffers on agricultural lands along Bay tributaries is underway.

***Forest Conservation Act***

Maryland's new Forest Conservation Act is being implemented across the state, and requires that a certain percentage of forest be left during the land development process, based on zoning categories.

### 4.4.3 *Nonpoint Source Program*

Implementation of Maryland's NPS Management Program relies on a strategy of interagency coordination and the application of laws and programs, which in total provide adequate control and management of nonpoint sources of water pollution. Thirteen statewide programs are included in Maryland's plan, including a silvicultural pollution control program. The NPS Management Plan provides for a linkage between the state's NPS pollution control programs and the Chesapeake Bay Program. A primary goal of the state's NPS Management Plan is to implement the Chesapeake Bay Nutrient Reduction Plan.

The Department of Natural Resources manages several incentive and assistance programs designed to reduce NPS pollution and improve water quality. Some of these include the Green Shores tree planting project along the Chesapeake Bay, the Buffer Incentives Program for private land owners, the Urban Grants Program for forestry projects in the critical area, and the Treemendous Maryland Program. In a special Rivers Project, including the Susquehanna and Monocacy watersheds, DNR foresters work closely with the agriculture community to encourage both forestry and agricultural BMPs.

The Maryland Forest Service (1993) has developed a BMP booklet in Field Guide form. A revision and update is planned for completion in 1998.

### 4.4.4 *Substate Programs*

***Chesapeake Bay***

While Maryland occupies only 14% of the 64,000 square miles contained in the Chesapeake Bay watershed, 94% of the land in Maryland drains into the Bay. NPS pollution and its contribution to water quality degradation has been identified as a major problem in the Bay watershed. Consequently, Maryland has incorporated goals to control these sources of pollution into its NPS

program. The 1987 Chesapeake Bay Agreement outlines six broad categories in which Bay protection efforts are focused: living resources, water quality, population growth and development, public information and education, public access, and governance. The major water quality goal of the Agreement is a 40% reduction in nutrient loadings to the Bay by the year 2000 (Chesapeake Bay Program 1992). A major initiative to plant streamside forest buffers has been announced.

### 4.4.5 *Instruction and Education*

The Maryland Forest, Park, and Wildlife Service conducts logger certification training seminars on water quality and BMP regulations. The state developed a BMP training course in 1990 sponsored by the Maryland Forestry Association, the Department of Natural Resources, the Cooperative Extension Service, forest conservation boards, and loggers (Hawkes et al. 1991). The Master Logger Program trains loggers in a variety of skills, including BMPs.

Consideration has been given to a program that would provide DNR foresters to check BMP installations on a non-enforcement basis in order to help operators learn the proper installation and maintenance of the practices. This is on hold pending resolution of right of entry and compliance issues.

### 4.4.6 *Compliance*

An extensive evaluation of compliance was conducted in 1994 (Koehn and Grizzel 1995). This survey included a mail survey of landowners and operators, and field visits to 99 logging sites (Table 4.3). Most of the landowners were aware of forestry and wetland BMPs (78% and 68%). In the mail survey, it was found that half of the contracts signed by operators required BMPs beyond the state's minimums.

The field sites were visited by groups that rated BMP compliance. Compliance overall was rated at 82% (Koehn and Grizzel 1995, p. 7), with the levels varying by types of practices.

**Table 4.3.** BMP Compliance by Category, Maryland, 1993 (99 Sites)

| Category | Compliance Rate |
|---|---|
| Haul roads and skid trails | 82% |
| Stream crossings | 75% |
| Log decks and landings | 90% |
| Soil stabilization | 68% |
| Streamside management zones | 83% |

Source: Koehn and Grizzel 1995, p. 7

The authors recommended that a similar survey be conducted periodically. A grant proposal has been made for a new survey. Further, they suggested that the Maryland Forest Service take the lead in BMP monitoring, that training be upgraded, and that efforts to educate landowners be expanded (Koehn and Grizzel 1995, p. 14).

### 4.4.7 *Effectiveness*

A Section 319 grant has been received for a paired watershed study, now in its fourth year. The study is being conducted in the Sugarloaf Mountain area in the Piedmont (Steve Koehn, MD DNR, pers. comm.).

### 4.4.8 *Current Research*

Eshelman (n.d.) of the University of Maryland is undertaking research on the role of insect defoliation in stream nitrogen content. Previous research has suggested an association between gypsy moth defoliation and stream nitrogen content in monitored watersheds.

### 4.4.9 *Current Policy Initiatives*

None.

### 4.4.10 *References*

Chesapeake Bay Program. 1992. *Progress report of the Baywide nutrient reduction reevaluation*. Review draft. February 1992. 68 pp.

Eshelman, K.N. n.d. *Assessment of forest disturbance in the Mid-Atlantic region: a multi-scale linkage between terrestrial and aquatic ecosystems*. Project proposal 97-NCERQA-16. University of Maryland, Frostburg.

Hawkes, L.J. et al. 1993. Forest water quality protection: a comparison of regulatory and voluntary programs. *Journal of Forestry*. May 1993. pp. 48-54.

Koehn, S.W., and Grizzel, J.D. 1995. *Forestry best management practices: managing to save the Bay. Assessment and analysis report on forestry BMP implementation in Maryland*. Annapolis: Maryland Department of Natural Resources; Forest Service.

Maryland Forest Service. 1993. *Soil erosion and sediment control guidelines for forest harvest operations in Maryland*. Annapolis. 120 pp.

Maryland Department of Natural Resources (MD DNR). 1996. *Maryland water quality inventory, 1993-1995*. Annapolis: Resource Assessment Service. 300 pp. + app.

Parker, W.H., Jr. 1990. How Maryland's Critical Area Protection Program is affecting timber harvesting. *Proceedings of the 1990 SAF National Convention*. Washington, DC. July 29-Aug 1.

Perdue, J.L. 1990. Maryland's experience with logging plan permits. Are forests the answer? *Proceedings of the 1990 SAF National Convention*. Washington, DC. July 29-Aug 1.

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#### 4.4.12 *Websites with Local Information*

Maryland Department of Natural Resources:
http://www.dnr.state.md.us/forests/index.html (follow buttons)

Department of the Environment:
http://www.mde.state.me.us

### 4.5 Massachusetts

#### 4.5.1 *Assessment*

The Commonwealth of Massachusetts reports that the limited base of information makes it difficult to fully assess the impacts of nonpoint sources on state waters. No identified impacts from silvicultural activities were included in their Section 319 assessment report. Although there is little information available about silvicultural sources of water pollution, there is recognition that timber harvesting activities pose a threat because of the potential for soil erosion and sedimentation, especially in small watersheds. A comprehensive review of the environmental impacts of timber harvesting in Massachusetts is provided in a 1992 General Environmental Impact Report (GEIR) prepared under the Massachusetts Environmental Policy Act. The 1996 Statewide Water Quality Assessment (Executive Office of Environmental Affairs 1997) mentioned no instances of silviculture as a source of pollution in reaches assessed. Approximately 800 logging operations occur in Massachusetts each year.

#### 4.5.2 *Forest Practice Regulation*

The Massachusetts Forest Cutting Practices Act (MGL Ch. 132, Sect. 40-46, administered by the Division of Forests and Parks in the DEM) regulates timber harvesting activities on all forestlands in the state (Quink 1992). The law addresses nonpoint source pollution resulting from wood harvesting activities and its impact on water resources, including wetlands, by incorporating BMPs into approved harvesting plans which are then legally binding.

Beyond the incorporation of BMPs in approved harvesting plans, forestry activities are also affected by the Wetlands Protection Act (MGL Ch. 131), which is administered at the local level (MA DEM 1996). Roughly half of logging operations involve wetlands issues. A comprehensive MOU with the DEM was signed in 1995. Under this MOU, compliance with ch. 132 is deemed to constitute

compliance with ch. 131. In 1995, the regulations were given a thorough revision (MA DEM, DF&P, n.d.).

A Watershed Protection Act was passed in 1992 calling for the protection of 300-foot buffer zones around reservoirs and 150-foot buffers along tributaries to those reservoirs.

### 4.5.3 *Nonpoint Source Program*

The state NPS program strategy relies on the effective administration and enforcement of the state Forest Cutting Practices Act. Program coordination is accomplished through a working relationship with the Division of Forest and Parks and related advisory committees.

BMPs are published in the *Massachusetts Forestry Best Management Practices Manual* (Kittredge and Parker 1995), available from the Massachusetts DEM. These guidelines are intended to clarify the requirements of the Cutting Practices Act (ch. 132) and the Wetlands Protection Act (ch. 131). The guidelines provide foresters and timber harvesters with BMPs designed to minimize erosion on harvesting operations that, if followed, will assure compliance with the forest practice and wetland laws. A detailed comparison of BMPs in use on the Metropolitan District Commission's Quabbin Reservation showed that practices were generally more strict than on other comparable properties (Watson 1997).

In other program actions, the state has prepared a Proposed Erosion and Sedimentation Act, which is still pending legislative action. Also, a new NPS "Mega-Manual," including existing silvicultural BMPs, has been prepared as general guidance for local Conservation Commissions, Boards of Health, and Planning Boards.

In Massachusetts, loggers are licensed. There are 500 to 700 licensed loggers. In their licensing exams they address questions dealing with BMPs.

Between 600 and 800 plans are filed yearly under the state's FPA. Every site is visited by a service forester, and "close-out" inspections are usually made. Less than half a dozen violations require enforcement action each year. The state foresters have authority to issue stop orders.

### 4.5.4 *Substate Programs*

None.

### 4.5.5 *Instruction and Education*

Training programs have been held on a regular basis. For 1998, state educators are planning to hold up to 30 "twilight workshops," entirely in the field, to review the rules onsite.

### 4.5.6 *Compliance*

In Massachusetts, compliance with forestry practices regulations is attained through implementation of the Forest Cutting Practices Act (Ch. 132). Compliance with provisions of this law and related regulations is reported in the Massachusetts Final GEIR:

> Evasion of the provisions of Chapter 132 by illegal cutting does not appear to be a significant problem. In FY 1986, Ch. 132 cutting plans accounted for 87% (98 million board feet) of the statewide annual harvest estimated by the U.S. Forest Service. Cuts under 25 MBF or 50 cords, particularly firewood cutting, easily account for the remaining 13%.
>
> Implications are that Ch. 132 accounts for almost all the jobs that are legally required to file a plan. Further, evasion or cheating is very minor, usually confined to operations at or near

the volume thresholds. Only 12 illegal operations were reported by Service Foresters in FY 1988 according to the Ch. 132 Subcommittee Report. Once discovered, these operations were shut down until proper notifications were made and plans were approved.

### 4.5.7 *Effectiveness*

In a study to determine, in part, the extent of erosion on logging roads resulting from harvesting and off-road vehicle (ORV) use, 530 completed harvesting operations covered by Ch. 132 were evaluated by DEM service foresters from July 1987 to June 1988 (MA DEM 1992). Erosion from logging was reported in 120 of the operations (23%). Erosion was routinely described as rutting, gullying, sedimentation, stream bank erosion, and exposure of bedrock. The severity of erosion was categorized. Almost 95% of the erosion was in the slight to moderate categories. In most cases, erosion was stabilized during or shortly after completion of harvesting. The most commonly reported corrective measures included construction of water bars, grading to remove ruts, and seeding. Natural revegetation also stabilized erosion (MA DEM 1992).

The effectiveness of some stream crossing techniques is reported by Thompson and Kyker-Snowman in a 1989 report. A three-part study was conducted involving: (1) an experimental stream crossings study designed to determine the extent of the impacts caused by crossing streams with logging equipment, and the effectiveness of mitigative measures in reducing impacts; (2) observations of currently active commercial logging; and (3) observation of logging jobs completed within the last several years. The effect of mitigation was dramatic. Unmitigated crossings generally caused large increases in turbidity at 15 and 100 feet downstream of the crossing. In some cases, an increase in turbidity was detectable at 1000 feet. Of the stream crossing structures tested, the portable bridge was the most effective in reducing crossing impacts. Visits to active harvesting operations found stream crossing mitigation practices on four out of the five operations visited. Stream siltation was noted on all five sites, with maximum turbidities ranging from 320 to 2 JTUs, depending on operational characteristics and type of stream crossing mitigation practice. On six inactive jobs visited, the researchers found postharvest erosion and siltation on three sites, one as old as four years. The authors conclude that the demonstrated effectiveness of the stream crossing techniques that were studied warrants the inclusion of stream crossing guidelines in the administration of the Forest Cutting Practices Act (Thompson and Kyker-Snowman 1989).

Additional assessments of the effectiveness of engineering and logging practices and measures to control erosion and protect water quality are reported in the Massachusetts Final GEIR. Extension and other officials have worked intensively on demonstrating portable skidder bridges (Kittredge, Woodall, and Haver 1997).

***Excerpts from Massachusetts GEIR***

> Studies evaluating engineering and logging measures used on permitted harvest operations indicate that these measures are successful in mitigating adverse environmental impacts. Based on data from Ch. 132 cutting plans... cutting plans worked well to fulfill the stated engineering objectives of the regulations. Patric (1988) routinely rated forest cutting as having no effect on soils based on his field observations. While areas of accelerated erosion due to logging were observed, they had stabilized and sediment production from most of the logged land remained close to the geologic norm. According to the ORV Subcommittee Report, Service Foresters reported that most erosion on harvesting operations was minimal resulting in few negative impacts and was stabilized during harvesting or shortly after its completion. Best management practices (BMP's) have been prepared for Massachusetts and numerous other states, and they have been shown to be effective throughout the nation in controlling erosion and sedimentation. (MA DEM 1992)

### 4.5.8 *Current Research*

None reported.

### 4.5.9 *Current Policy Initiatives*

In 1995 there were several minor revisions to the BMPs, but at present there are no policy initiatives underway in the area of forestry BMPs. A bill providing for forester licensing has passed; implementation is underway.

### 4.5.10 *References*

Executive Office of Environmental Affairs. 1997. *Commonwealth of Massachusetts summary of water quality, 1996*. Worcester: Department of Environmental Management. 136 pp.

Kittredge, D.B., Woodall,C., and Haver, N. 1997. Massachusetts loggers rate portable skidder bridges. *Northern Logger and Timber Processor*. Oct. pp. 26-27, 36.

Kittredge, D.B., and Parker, M. 1995. *Massachusetts forestry BMP manual*. Massachusetts Department of Environmental Management, Office of Watershed Management; and USEPA Region I.

Massachusetts Department of Environmental Management (MA DEM). 1996 *Wetlands Protection Act regulations (310 CMR 10.00) for administering MGL ch. 131, Sec. 40*. Bureau of Resource Protection, Division Wetlands and Waterways. 154 pp.

———. n.d. *Ch. 132 guidance document, Massachusetts' Forest Cutting Practices Act (MGL ch. 132, s. 40-46)*. Division of Forests and Parks. 40 pp.

———. 1992. *Final (draft) general environmental impact report (GEIR) on forestland management practices*. Division of Forests and Parks. 373 pp. + app.

Patric, J.H. 1988. *A comparison of planned with established forest practices in Massachusetts*. Massachusetts Department of Environmental Management, Division of Forest and Parks, Boston: 48 pp.

Quink, T.F. 1992. The Massachusetts forest cutting act experience. In: *Proceedings of the Society of American Foresters 1992 Annual Convention*. pp. 468-471.

Thompson, C.H., and Kyker-Snowman, T.D. 1989. *Evaluation of nonpoint source pollution problems from crossing streams with logging equipment and off-road vehicles in Massachusetts*. Massachusetts Department of Environmental Quality Engineering, Research and Demonstration Project 88-03.

Watson, B.C. 1997. *Comparative analysis of timber harvest BMP's*. MDC-Quabbin, Providence Water, Hartford MDC, and Pennsylvania Bureau of Forestry, Michaux State Forest. Prepared for the Northeast National Resource Center, National Wildlife Federation 19 pp.

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## 4.6 New Hampshire

### 4.6.1 *Assessment*

According to the 1992 State Assessment Report, “Silviculture is not known or perceived to be a significant contributor of NPS pollution to surface or groundwaters.” “Local erosion and subsequent sedimentation problems occur, but are ephemeral. Problems are due to inappropriate or inadequate application of BMPs. Silviculture is a nonpoint source pollution problem of minor significance statewide and moderate to major significance in some watershed sub-units.” In its 1996 Assessment (NH DES 1996, p. III-3-11) there were no miles of streams unable to fully support uses due to silvicultural sources of pollution.

In 1992, a Clearcutting Study Committee declined to recommend regulation of clearcuts in New Hampshire, but suggested that BMPs for clearcuts be developed and that data be collected to track

clearcut acreage in the state. A later study documented the extent of clearcutting in the state (Rubin and Justice 1995).

### 4.6.2 *Forest Practice Regulation*

General state forestry laws include a basal area removal limit on timber harvesting in areas around surface waters and along public roads, plus slash control and some other forestry practice regulations (RSA 227-5:9; RSA 227-5:10).

The state severance tax law requires the filing of an intent-to-cut notice with the local municipality, signed by a logger or other responsible person. The notification contains a tear-off, which goes to the Wetlands Bureau, DES. This form certifies that the operation will meet the minimum impact requirements of the Wetlands Protection Law, which includes adherence to published BMPs (RSA 485-A:17, RSA 482-A). For this reason, the state's environmental agency views the program as regulatory.

### 4.6.3 *Nonpoint Source Program*

The implementation strategy in New Hampshire is to work with a variety of agencies and others to carry out a program of information and education (NH DES 1989). The state's overall strategy is described in its recent 305(b) report (p. II-2-18). This discussion does not mention forestry issues. The 1989 version of the Plan briefly discusses them.

BMPs are published as *Best Management Practices for Erosion Control on Timber Harvesting Operation in New Hampshire* (Cullen 1996), available from the Division of Forests and Lands, Department of Resources and Economic Development. Additional guidelines are available (New Hampshire forest Sustainable Standards Workteam 1997).

In New Hampshire, the State Forest Service has a ten-person staff for enforcing forestry regulations related to fire control and other matters. Based on required tax reporting, they estimate that about 5000 logging operations take place in New Hampshire in an average year. Routine inspections include examining permit compliance with wetland and stream crossing regulations. About 3000 inspections are made each year. Wetland buffer guidelines have also been developed for New Hampshire municipalities (Chase, Deming, and Latawiec 1997).

Violations may involve both wetlands rules and water quality impacts. There is no database on the occurrence of violations, but it is estimated that 100 situations are referred to the Wetlands Bureau for action each year. Rangers have the authority to order an operation to cease and desist, but this is rarely done. When necessary, it can be done for that portion of a job that is not in compliance. Rangers can order a logger to cease skidding through a particular stream until a proper crossing is installed. Work may proceed on the balance of the job. The most common violations involve skidding in brooks and failure to complete recommended steps for putting an operation to bed.

The enforcement approach is to seek compliance and remediation first; if this is accomplished further enforcement actions are not taken.

The state's suggested Standard Timber Sale Contract includes reference to BMPs.

### 4.6.4 *Substate Programs*

None.

### 4.6.5 *Instruction and Education*

Instruction and education activities are coordinated with the Cooperative Extension Service. In the past, a series of forest management workshops have been held which included training on BMPs. An ongoing cooperative training effort is underway, coordinated by the New Hampshire Timber Harvesting Council.

The Grafton County Demonstration Project is a conservation district project to provide a demonstration of the proper installation of a small brook skid trail crossing that minimizes wetland damage and controls erosion on skid trails. A thorough, well-illustrated manual of recommended sustainable forestry practices was issued in 1997.

### 4.6.6 *Compliance*

No formal field analyses of compliance or effectiveness are available in New Hampshire.

### 4.6.7 *Effectiveness*

Extensive work at Hubbard Brook has shown that BMPs provide water quality protection when properly used. BMPs do not eliminate all impacts and can be overwhelmed by storms of unusual intensity.

### 4.6.8 *Current Research*

None was reported, beyond ongoing work at Hubbard Brook on related subjects. A need for an objective compliance survey is informally recognized within the New Hampshire Forest Service.

### 4.6.9 *Current Policy Initiatives*

There are no significant new policy or administrative measures underway. A committee on "liquidation cutting" is expected to report in 1998, after holding public meetings in late 1997. The state has negotiated MOUs on management of high-elevation lands with two large private owners, Crown Vantage and Champion International (Anon. 1996b). One objective is to protect water quality.

### 4.6.10 *References*

Anon. 1996b. MOU for high-elevation forest management, between Champion International Corporation, NH Fish and Game Department, and NH Division of Forests and Lands. Concord. Oct. 29. 12 pp.

Chase, V., Deming, L., and Latawiec, F. 1997. *Buffers for wetlands and surface waters: a guidebook for New Hampshire municipalities*. Concord: Audubon Society of New Hampshire. 80 pp.

Cullen, J.B. 1996. *BMP's for erosion control on timber harvesting operations in New Hampshire*. Concord: New Hampshire Division Forests and Lands and Cooperative Extension Service Forestry and Wildlife Resources Program. 65 pp.

New Hampshire Department of Environmental Services (NH DES). 1989. *New Hampshire NPS management plan*. Concord. Especially Appendix F.

———. 1996. *State of NH 1996 Sec. 305(b) water quality report*. Concord. var. pg.

New Hampshire Forest Sustainability Standards Workteam. 1997. *Good forestry in the Granite State: recommended voluntary forest management practices for New Hampshire*. Concord:

New Hampshire Division Forests and Lands and the Society for the Protection of New Hampshire Forests. var. pg. (Notebook format).

Rubin, F., and Justice, D. 1995. *Final report: New Hampshire timber clear cut inventory*. Durham: University of New Hampshire; Complex Systems Research Center. 12 pp. + app.

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#### 4.6.12 *Websites with Local Information*

http://www.state.nh.us/des/2bb-36.htm

### 4.7 New Jersey

#### 4.7.1 *Assessment*

New Jersey has significant cold water fisheries in the heavily forested northwestern portion of the state. It also has water quality concerns in farming areas and in the Pinelands area. The state produces only modest amounts of commercial forest products, largely because of distances from mills, the small size of forest ownerships, and owner objectives. Because of past water uses and the condition of the resource, the DEP views the state's waterways, even those supporting designated uses, as "threatened." The 1994 Section 319 report mentions silviculture as a moderate/local/minor source of water quality impact on waters (NJ DEP 1995, p. 111-114). Roughly 240 logging operations occur in New Jersey each year. The state's Coastal Zone Management Program received a categorical exemption for forestry (Benoit and Fox 1997).

#### 4.7.2 *Forest Practice Regulation*

Under state and federal water quality laws, state waters are to be protected from degradation affecting their designated uses. In addition, the Freshwater Wetlands Protection Act "regulates forestry activities conducted within forested wetlands and transitional areas (buffers). Specific forestry activities have been granted a conditional exemption of the requirement of needing a wetlands permit" (New Jersey Bureau of Forest Management 1995, p. vi). These buffers may extend up to 150 feet from the wetland boundary. The exemption is available for lands being managed under an approved forest management plan. This program is administered jointly by the Land Use Regulation Program and the Bureau of Forest Management.

#### 4.7.3 *Nonpoint Source Program*

The state's NPS Program is described in the Section 319 report (p. v-5 ff). The state is moving toward a watershed approach to NPS management. A highly detailed overview is provided in NJ DEP (1997). A new Nonpoint Source Assessment and Management Program is planned for draft release in September 1998.

State forestry officials report that potential negative water quality impacts have been addressed through recommendations contained in a timber harvesting guidelines publication (New Jersey Bureau of Forest Management 1995). A wetlands forestry manual has been prepared which augments the timber harvesting guidelines.

In New Jersey, permits are required for activities in wetlands and waterway buffers (New Jersey Freshwater Wetlands Protection Act). The NJFS will conduct an onsite review of the application of BMPs at an operator or forester's request. The review is documented with a letter. Operations receiving this letter are inspected later only if a problem or violation is reported.

Forestry has seven field staffers who are available for inspections. They are also responsible for state land management, forest stewardship, advice on private land, and inspections on farmland tax assessment.

#### 4.7.4 *Substate Programs*

The Pinelands area in southern New Jersey comprises part or all of 53 municipalities (Pinelands Commission 1985). Forestry application requirements and standards for the Pinelands area are

contained in the Pinelands Comprehensive Management Plan (NJAC 7:50-6.41 through 6.447). These application requirements and forestry standards are also reflected in municipal land use ordinances within the Pinelands area. These forestry standards address required management practices, including those designed to protect and maintain surface water quality.

Throughout New Jersey, forestry practices can also be regulated under municipal tree cutting ordinances.

#### 4.7.5 *Instruction and Education*

A well-illustrated and thorough BMP manual has been prepared (New Jersey Bureau of Forest Management 1995).

#### 4.7.6 *Compliance*

No known work.

#### 4.7.7 *Effectiveness*

No known work.

#### 4.7.8 *Current Research*

A new NPS draft program is to be released in September 1998.

#### 4.7.9 *Current Policy Initiatives*

A watershed approach is being developed, and TMDL issues are under consideration.

#### 4.7.10 *References*

Benoit, J. (National Oceanic and Atmospheric Administration), and J. Fox (US EPA). 1997. Letter to R. Shinn, Commissioner, NJ DEP, conditionally accepting Coastal Zone Act Reauthorization Amendment (CZARA) program, Nov. 18, 1997. 14 pp.

New Jersey Bureau of Forest Management. 1995. *NJ forestry and wetlands BMP manual*. Trenton. 31 pp.

New Jersey Department of Environmental Protection (NJ DEP). 1995. *New Jersey 1994 state water quality inventory report*. Trenton. var. pg.

———. 1997. *Draft statewide watershed management framework document for the State of New Jersey*. January. 78 pp.

New Jersey Freshwater Wetlands Protection Act. NJSA 13:93-1, et seq.

New Jersey Freshwater Protection Act Rules. NJAC 7:7A.

Pinelands Commission. 1985. *The Pinelands of New Jersey*. Brochure.

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## 4.8 New York

### 4.8.1 *Assessment*

According to the state assessment report, water quality problems resulting from timber harvesting tend to be localized and of short duration. Other silvicultural activities are not considered to be water quality threats in New York. Sedimentation is the principal water quality impairment associated with harvesting, and is believed to be caused by erosion from poor design and placement of logging roads, trails, or landings. An estimated 6000 logging operations take place in New York each year.

In a field survey to update the NPS program assessment, only 5 out of 1426 water samples were affected by silvicultural sources (NYSDEC, Water Division 1997, p. V-83). In 11 additional lake segments and 26 stream segments sampled, silviculture was determined to be a secondary source.

### 4.8.2 *Forest Practice Regulation*

***Protection of Waters Program (ECL Art. 15, Title 5)***

Permits are required to disturb the banks and beds of "classified" streams (even when dry) or to excavate or fill navigable waters. Classified streams are those streams and stream segments identified by statute or regulation as subject to the Protection of Waters Program. A new Standard Activity Permit Process (SAPP) establishes a streamlined permit process that allows stream crossings as long as they are in conformance with established BMPs and other provisions.

***Wild, Recreational, and Scenic Rivers Program (ECL Art. 15, Title 27 and Regulations, Sect. 666.26 and 666.31)***

Timber harvest (cutting) is subject to aesthetic and water quality protection standards along designated river segments, mostly in the Adirondack Park and Regions 1 and 3 (Long Island and New York City to Albany area).

***Adirondack Park Agency***

APA regulates the size of clearcuts and places restrictions on harvesting in wild, scenic, and recreational river corridors, wetlands, and shorelands on private lands within the Adirondack Park.

***Forest Practices Board***

A statewide Forest Practices Board advises the DEC and adopts standards for forest practices. Regional boards also exist. In a few instances, regional boards have been active on water quality issues. The standards have generally not created significant regulatory requirements. An effort is now underway to reorganize this program.

***Local Ordinances (General Municipal Law, Sect. 2, 96-B)***

In New York, communities are empowered to enact local ordinances to provide for the protection and conservation of trees and related vegetation. The DEC has produced a Model Timber Harvesting Ordinance. In 1990 there were 49 such ordinances, mostly in the Hudson Valley and in suburban towns. Ordinances are enacted in response to road damage concerns, visual impacts, and concern for the lack of any plan (Anon. 1992). Because of the urban orientation of local ordinances, the existing set of ordinances was not believed to have a significant impact on the forest industry in New York. However, by 1993 there were 123 towns with such ordinances, and industry concern over their extent and stringency was growing (ESFPA 1997).

### 4.8.3 *Nonpoint Source Program*

The state's program for dealing with water quality problems associated with silviculture is coordinated by the DEC, Division of Lands and Forests. The state strategy relies on information and education (technology transfer) to promote the use of sound management practices. The program appears to be adequate, but is limited by the availability of existing funding. BMPs for water quality protection are included in Timber Harvesting Guidelines, published by the New York State Department of Environmental Conservation. BMPs for silviculture (which cover water quality protection as well as other purposes) are published by DEC and incorporated into a joint DEC/NYS Timber Producers Association Cooperating Timber Harvester Program.

New York is updating its NPS Program at this time, with completion expected in 1998. Administration is primarily at the level of the nine DEC Administrative Regions. Based on individual problems, staff activities, and other factors, the personnel involved may be from any of

three agencies, Water, Fish and Wildlife, or Forestry. Program data are maintained at these offices. Unless a specific permit is required, there is no general notification requirement for logging jobs, and there is no estimate of the number of logging jobs taking place in the state in any given year. The most frequent violations include poor stream crossings and skidding in the streams; there is no state-level information maintained on this point. A detailed summary of program actions and agencies involved is in the NPS Program Draft at p. V-85 ff.

The New York State program includes:

***Cooperating Consultant Forest Program***

This program is based on a cooperative agreement between the state and consulting foresters. The state publishes a list of consultants and their services, and encourages forestland owners to seek and use their advice. The state also provides training and coordination with public programs. Consultants agree to adhere to laws and regulations, provide activity reports, and adhere to a code of ethics.

***Cooperative Timber Harvesting Program***

The New York Logger Training Program, Inc. is based on a cooperative agreement between the state DEC and the New York State Timber Producers Association. The program is guided by a Policy and Procedures Plan, and incorporates BMPs. Under this program, small landowners receive technical assistance in management planning and timber harvesting.

### 4.8.4 *Substate Programs*

***New York City Watershed Forestry Program***

Major reservoirs in the Catskills supply drinking water for New York City. In order to avoid the need to install costly filtration plants, a major effort is underway to apply BMPs to forestry, farming, and development to maintain and enhance water quality. Cornell Cooperative Extension is playing a major role. Programs include funding for forest management plans, cost sharing for BMPs, education, demonstration forests, and economic development (Anon. 1996c; Catskill Center 1997).

***Adirondack Park Agency***

The Adirondack Park has a legendary history in the Northeast. It was first created in the late 19th century by constitutional amendment (APA 1996). A so-called “Blue Line” defines the Park’s outer limits; today it encompasses one-fifth of the state’s land area. Within its boundaries, all remaining state-owned lands were to be managed in a “Forever Wild” condition. Acquisitions since then have brought the state-owned total to 2.3 million acres. In the late 1960s, the completion of interstate highway links to the region brought an increase in visitation and development pressures. The APA was created in 1971 to provide a planning and regulatory authority not only for the state-owned lands, but also for the 3.7 million acres of private land inside the Blue Line.

The Agency administers three laws relating to forestry:

1. APA Act. Regulations under this law limit the size of upland clearcuts to 25 acres without a permit (APA 1982)
2. Freshwater Wetlands Act. This act protects wetlands.
3. Wild, Scenic, and Recreational Rivers Systems Act. Many of the rivers designated under this Act are in the Adirondacks; the rules limit harvesting in streamside zones.

Regulations by the DEC, as elsewhere in the state, provide for water quality protection practices involving roads, culverts, and harvesting (APA, n.d. p. 11).

### 4.8.5 *Instruction and Education*

In addition to formalized programs with consulting foresters and timber harvesters, the state supports information and education programs provided by the College of Environmental Science and Forestry at Syracuse, the Cornell Cooperative Extension Program, and the New York Logger Training Program, Inc. A group of institutions is engaged in a long-term training program, including a certification program. There are now some 250 certified loggers in New York. Approximately 1400 have attended one or more training events.

### 4.8.6 *Compliance*

A recent field evaluation found that compliance with voluntary guidelines was low, but there was no evidence of any difference in erosion occurring as a result of noncompliance. This report is a post-timber harvest analysis of New York State's "Timber Harvester Guidelines" (THGs). The Guidelines are a Best Management Practices program targeted at minimizing the impacts of timber harvest on soil erosion. This program was developed in compliance with Section 208 of the 1972 Federal Clean Water Act Amendments (PL 92-500), and continues under the auspices of Section 319 of the 1987 Water Quality Act. As compliance with the THGs is currently on a voluntary basis, there was a need to evaluate the program's effectiveness, both in terms of the degree of compliance and in the extent to which the guidelines, when implemented, have mitigated soil losses on harvest sites. The data provided herein is the result of a two-year postharvest survey conducted by Department of Environmental Conservation foresters. The results of this analysis show a relatively low level of compliance with the guidelines, yet there appears to be little erosion occurring when compared to the potential for erosion damage from harvest operations. Both a scatterplot diagram and linear regression equations show little correlation between the degree of compliance and the occurrence of harvest damage (King 1989).

### 4.8.7 *Effectiveness*

None reported since 1989 (see previous section).

### 4.8.8 *Current Research*

Prof. R. Briggs of SUNY-CESF has initiated a field survey of BMP compliance and is seeking additional funding for continuing and extending the work (Briggs 1997). Work at the Huntington Forest (Arbutus Lake) emphasizes biogeochemistry of unmanaged watersheds. The Neversink Watershed Research Program is seeking to understand how management affects nitrogen and nutrient content of streamwater.

### 4.8.9 *Current Policy Initiatives*

Completion of statewide NPS program; revision of Catalog of BMPs.

### 4.8.10 *References*

Anon. 1992. *Timber harvesting ordinances in New York*. NYSAF Meeting, January 24, 1992.

———. 1996c. *Whole farm planning*. Walton: Watershed Agr. Council. 12 pp.

Adirondack Park Agency (APA). n.d. *Citizen's guide to Adirondack forestry*. 23 pp.

———. 1982. *APA rules and regulations*. Oct. 15. Subtitle Q, Title 9. 126 pp. + app.

———. 1996. *APA 1995 annual report*. Ray Brook. 24 pp.

Briggs, R.D. 1997. *Assessing forestry BMP compliance and effectiveness on harvested sites in NY Part II*. State University of New York, College of Environmental Science and Forestry. Processed. (Project proposal.)

Catskill Center for Conservation and Development, Inc. 1997. *Summary guide to the terms of the watershed agreement*. Arkville, NY. 31 pp. + app.

Empire State Forest Products Association (ESFPA). 1997. *Local regulation of timber harvesting in New York State*. Albany. 4 pp.

King, K.S. 1989. *An Analysis of New York State's Timber Harvesting Guidelines*. Department of Environmental Conservation. Unpublished report.

New York State Department of Environmental Conservation (NYSDEC), Division of Water. 1997. *Draft nonpoint source management program, 1997 update*. Albany. var. pg.

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#### 4.8.12 *Websites with Local Information*

http://www.dec.state.ny.us

### 4.9 Pennsylvania

#### 4.9.1 *Assessment*

The State 305(b) Assessment Report (PDER 1996) cites a severe lack of data on the occurrence and causes of silviculturally related problems. Consequently, silvicultural sources of water pollution are not documented, even though timber harvesting is common in the Commonwealth. The state's NPS assessment shows that the bulk of stream mileage affected by NPS is from mine drainage and agriculture. The 1996 Assessment Report notes that a complete update of the NPS assessment will be conducted. An estimated 12,000 logging operations are conducted in Pennsylvania each year.

In an assessment of resource problems of Chesapeake Bay (of which Pennsylvania's Susquehannah River is the major water source), writers Horton and Eichbaum (1991, p. 267-277) noted that logging can be a significant sediment source, but did not identify such sedimentation as a major overall basinwide concern compared to farming and urban sources. They did, however, emphasize that many streams possess inadequate forest buffers, and they pointed to the loss of forest cover in the watershed as a serious problem (p. 133).

#### 4.9.2 *Forest Practice Regulation*

Under the state's Erosion and Sedimentation Pollution Control Program (Ch. 102, Title 25 Pennsylvania Code), an erosion and sedimentation (E&S) control plan and/or permit is required for all soil disturbing activities, including timber harvests and logging roads. Current practice requires an E&S control plan to be prepared and available on site if 25 or less acres are disturbed. Under Ch. 105, permits are required to alter wetlands; under General Permits, minor alterations are allowed under specific conditions.

A permit is required to disturb more than 25 acres. The Governor has launched a wetlands protection initiative that may include some road fill standards for logging roads. These would allow for temporary road fills in order to reach inaccessible areas. A useful summary of regulations is found in Anon. (1996a). At least 135 local governments in the Commonwealth have forest practice or logging regulations.

#### 4.9.3 *Nonpoint Source Program*

The Bureau of Forestry's NPS program "is primarily geared toward educating loggers about environmentally sound silviculture, and erosion and sediment pollution control practices. This training consists of structured classroom sessions, distribution of published materials, and on-site assistance provided by 45 Service foresters located throughout the state." The Legislature and the DEP have endorsed the approach of using voluntary BMPs.

The DEP administers Pennsylvania's Erosion and Sedimentation Pollution Control Program, which applies to timber harvesting and forest road building activities (PDER 1992, n.d.). The program is implemented through a delegation of authority to County Conservation Districts, which includes review of erosion and sedimentation control plans and site compliance inspections. Notification and complaint procedures vary from county to county. A resource package has been developed for loggers (PSU and DER n.d.).

The Bureau of Forestry has a set of BMP manuals developed in cooperation with the DEP and Penn State University (PSU) (Brown 1993; Anon. 1996a). A set of BMP Guidelines has been published, as well as a recent manual titled *Using BMPs to Prevent and Control Pollution from Hardwood Residue Storage Sites*. A multi-agency Dirt and Gravel Roads Task Force is developing methods to control dust and erosion from the state's 5000 miles of such roads in forested areas.

#### 4.9.4 *Substrate Programs*

Chesapeake Bay Program (see below).

#### 4.9.5 *Instruction and Education*

In the early 1980s, leading insurance companies established a logger certification program. This initiative ended, and has been replaced by an effort of the American Forest and Paper Association's Sustainable Forestry Initiative (SFI) Committee to provide training in operations, safety, silviculture, and forestry laws. Of a total of 3000 loggers, some 1100 have received training in BMPs.

Penn State Cooperative Extension is working with the Bureau of Forestry in an active forest stewardship program, which includes environmental concerns.

#### 4.9.6 *Compliance*

There are no surveys dealing exclusively with BMP compliance. In a field survey of sustainable cutting practices, a PSU graduate student took incidental observations on BMPs or conditions related to water on logging jobs. Results are expected in a 1998 thesis (J. Finley, PSU, pers. comm.).

#### 4.9.7 *Effectiveness*

A detailed evaluation of the effectiveness of BMPs has been conducted at the Leading Ridge Experimental Watershed in Central Pennsylvania. As the authors summarized:

> Fifteen years of streamflow and water quality data were evaluated to determine the effectiveness of Best Management Practices (BMPs) in controlling nonpoint source

> pollution from an 110-acre commercial clearcut located in the Ridge and Valley Province of central Pennsylvania. The analyses addressed both short- and long-term changes in the physical and chemical properties and the hydrologic regime of the stream draining this 257-acre watershed. Overall, the BMPs employed on this commercial clearcut were very effective in preventing serious deterioration of stream quality as a result of forest harvesting. Although statistically significant increases in nitrate and potassium concentrations and temperature and turbidity levels were measured the first two years following harvesting, the increases were relatively small and, with the exception of turbidity, within drinking water standards. Nevertheless, such increases may violate EPA's anti-degradation policy. Nitrate and potassium concentrations and turbidity levels remained above pre-harvesting levels for as long as nine years following harvesting. Clearcutting also significantly increased water yield, which in turn initially lowered the concentrations of most solutes because of dilution. Increased water yields returned to pre-harvesting levels within four years as a result of rapid regrowth. The export of some ions increased; however, the increased export appeared to be insufficient to affect site fertility. Implementation of periodic postharvest inspections of harvested areas, increasing the width of the buffer zone, and utilizing buffer zones on all perennial and intermittent channels would reduce further impacts of silvicultural activities on water quality. (Lynch and Corbett 1990, p. 41)

A detailed assessment by Trieu and Arnold (n.d.) examined the effect of road surfacing on erosion from logging roads on the Allegheny National Forest. This study involved unusually detailed monitoring, including measurement of streambed conditions in the receiving waters.

A detailed field assessment examined a large statewide sample of 70 forest road crossings, mostly over streams, examining effects in detail. Roughly half of the crossings were culverts. The streams studied were primarily first- and second-order streams. The streambed conditions below the crossings were different from upstream conditions in only 35 instances of 814 comparisons made. Overall, the authors concluded that "little long-term impact to habitat quality channel stability, vegetation, wetland width, and channel embeddedness was found" (Miller et al. 1997).

#### 4.9.8 *Current Research*

Ongoing work at Leading Ridge.

#### 4.9.9 *Current Policy Initiatives*

A riparian reforestation program has received some attention (PDEP 1998).

#### 4.9.10 *References*

Anon. 1996a. *BMP's for Pennsylvania forests*. University Park: Penn State University. 48 pp.

Brown, D.B. 1993. *BMP's for silvicultural activities in Pennsylvania's forest wetlands*. Penn State University, School of Forest Resources. 53 pp.

Horton, T., and Eichbaum, W.M. 1991. *Turning the tide: saving Chesapeake Bay*. Covelo, CA: Island Press.

Lynch, J.A., and Corbett, E.S. 1990. Evaluation of BMP's for controlling nonpoint pollution from silvicultural operations. *Water Resources Bulletin*. 26(1):41-52.

Miller, R.L., Jr., DeWalle, D.R., Brooks, R.P., and Finley, J.C. 1997. Long-term impacts of forest road crossings of wetlands in Pennsylvania. *Northern Journal of Applied Forestry* 14(3): 109-116.

Pennsylvania Department of Environmental Protection (PDEP). 1998. *Pennsylvania stream releaf: A plan for restoring and conserving buffers along Pennsylvania streams*. Draft. Department of Environmental Protection Publication 3940-Bk-DEP2216. 23 pp. + app.

Pennsylvania Department of Environmental Regulation (PDER). n.d. *General permit, BDWM-GP-8. Temporary road crossings*. Harrisburg. Bureau of Dams and Waterway Management.

———. 1996. *Commonwealth of Pennsylvania 1996 water quality assessment*. Harrisburg. 94 pp.

Pennsylvania Department of Environmental Regulation (PDER), et al. 1992. *Controlling erosion and sedimentation from timber harvesting operations*. University Park: Penn State University. 26 p. (pocket format)

Pennsylvania State University (PSU) and Pennsylvania Department of Environmental Regulation (PDER). n.d. *Controlling erosion and sediment pollution from timber operations "Prof. timber harvesters action pocket."* Containing summaries of rules, permits, lists of agencies, etc.

Trieu, P.L., and Arnold, D.E. n.d. *Assessment of physiochemical and biological effects of two types of road surface on adjacent streams*. University Park: Pennsylvania Cooperative Fish and Wildlife Research Unit. 98 pp.

(Note: in the mid 1990s, the Penn Department of Environmental Regulation was split into the present DEP and DCNR.)

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Department of Conservation and Natural Resources: http://www.dcnr.state.pa.us

### 4.10 Rhode Island

#### 4.10.1 *Assessment*

Potential silvicultural problems are recognized, but "logging occurs on a fairly limited basis in Rhode Island," and silvicultural impacts are limited. According to the state's NPS Program (RI DEM 1995, p. 2-38) document, "silvicultural practices pose no documented threat to water quality." The state argued for exclusion from special requirements under the Coastal Zone Management NPS Program, on grounds that "no Rhode Island plan or report documents impacts from silviculture" (RI Coastal NPS Program 1995).

#### 4.10.2 *Forest Practice Regulation*

Under Rhode Island's Wetlands Protection Law, any logging operation affecting a wetland area, including any entailing a stream crossing, must submit an application for a wetlands determination from RI DEM's Freshwater and Wetlands Section. For streams 10 feet in width or less, a 100-foot buffer is required. For wider streams, the buffer is 200 feet. Managed logging activities using BMPs and with an intent-to-cut form filed with the Division of Forest Environment or an approved Forest Management Plan submitted under the Farm Forest Open Space Act or the Stewardship Incentive Program are exempt from permit filing requirements. All logging operations are required to file a notification form if more than 25 cords or more than 5 acres are being cut. Staff from the Division of Forest Environment make an effort to inspect all operations at least once. Violations are reported to the DEM Office of Compliance and Inspection for action.

### 4.10.3 *Nonpoint Source Program*

Rhode Island adopted an updated NPS Program in 1995 which included discussion of forest practices. The program emphasizes continued use of the notification requirement, training in the use of the new BMP publication (Cassidy, Aron, and Tremblay n.d.), and continued use of the wetlands regulatory system.

In Rhode Island, slopes are modest, logging operations are small, and soils are sandy and well drained. In most of the state, upland settings are relatively erosion-resistant. Water quality impacts from forestry are reportedly infrequent and minor. Forestry officials emphasize education and training in BMPs. There is no staff specifically dedicated to BMP inspections, but a forester from the DFE visits each operation filing a notification at least once. The enforcement philosophy emphasizes compliance and remediation as the first priority. Since issuing more specific enforcement rules in 1994, environmental officials report that referrals for enforcement have been infrequent. About 200 logging operations occur each year, and about 70 notification to cut forms are filed each year.

### 4.10.4 *Substate Programs*

None.

### 4.10.5 *Instruction and Education*

Workshops have been held to train landowners and loggers in the use of BMPs.

### 4.10.6 *Compliance*

No research reported.

### 4.10.7 *Effectiveness*

No research reported.

### 4.10.8 *Current Research*

None reported.

### 4.10.9 *Current Policy Initiatives*

A state commission is studying ways to streamline environmental regulatory processes. A watershed approach to planning is being implemented.

### 4.10.10 *References*

Cassidy, G.J., Aron, J.B., and Tremblay, M.J. n.d. (ca. 1996). *Best management practices for Rhode Island: water quality protection and forest management guidelines*. N. Scituate: RI Department of Environmental Management, Division of Forest Environment. 49 pp.

Rhode Island Coastal NPS Control Program. 1995. Response to NOAA/EPA comments on Rhode Island's threshold review. Providence, DEM. Ch. 5, Forestry. 9 pp.

Rhode Island Department of Environmental Management (RI DEM). 1995. *Rhode Island NPS management plan*. NPS Program and Division of Planning, Report No. 87. var. pg.

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### 4.10.12 *Websites with Local Information*

http://www.state.ri.us/dem

## 4.11 Vermont

### 4.11.1 *Assessment*

According to Vermont's Nonpoint Source Assessment Report (August 1988), "Silvicultural nonpoint pollution in Vermont is largely confined to the activities of harvesting, residue management, and logging road construction/maintenance. Although only 45 miles of rivers or streams were found to be impacted during the Nonpoint Assessment, it is suspected that additional rivers or stream miles have impacts from logging activities but went undetected due to the remote and often mobile nature of the industry." Roughly 2000 logging operations occur in Vermont annually.

In a subsequent postharvest assessment of Vermont's acceptable silvicultural management practices, Brynn and Clausen (1991) report increased stream sedimentation from 46% of logging operations involving a stream. Soil erosion was generally related to roads, skid trails, and log landings. The Vermont Division of Forestry is responsible for responding to water quality complaints and problems related to forestry practices, and prepares a summary of these activities annually. In recent years there has been a downward trend in reported problems, which is attributed to education and enforcement of AMP (Acceptable Management Practices) regulations (Brian Stone, pers. comm).

Faculty at the University of Vermont prepared a report on the impacts of timber harvesting which includes a section on water quality (UV 1990). Timber harvesting activities were examined for impacts on water quality and for compliance with existing statutes. Lingering water quality impacts, including increased stream temperature and turbidity, woody debris, and petroleum spills, were infrequent and insignificant. The primary impact to water quality was increased sedimentation. Sediment increases were observed in nearly one-third of the operations that involved a stream, lake, or wetland. Although some sediment originated from truck roads, skid trails, and log landings, the primary source of sediment appeared to be improper stream crossings. Over one-half of operations with stream crossings exhibited sediment impacts (UVM 1990). Brian Stone of the Vermont Department of Forests, Parks, and Recreation, points out that this study was prepared prior to the recent adoption of AMPs as regulations under the state's water quality law.

### 4.11.2 *Forest Practice Regulation*

Vermont has no Forest Practices Act. Under 1986 amendments to Vermont water quality protection statutes (10 VSA 1259), forest practices are subject to Acceptable Management Practices (AMPs are equivalent to BMPs) that have been adopted as regulations. The Vermont Division of Forestry, under a Memorandum of Agreement with the Department of Environmental Conservation, provides preliminary enforcement in the form of first response to complaints, using members of the Vermont Forest Products Association to counsel and achieve compliance. Additional legal enforcement is provided by the Department of Environmental Conservation as needed.

A Heavy Cutting Law (10 VSA, 2622), now in effect, requires notification to the state of cuts that reduce residual basal areas below the "C line" on 40 acres or more (Vermont Dept. FP&R 1997). Other than this, however, there is no notification requirement. The "C line" is a level of residual stand stocking based on widely used strategy guides. The program is currently under "emergency rules" and is highly controversial, to say the least. This program has no specific water quality elements.

### 4.11.3 *Nonpoint Source Program*

The Vermont NPS program relies on a cooperative working relationship with the Vermont Division of Forest and other agencies and groups with an interest in forest resources.

A set of BMPs are published as *Acceptable Management Practices for Maintaining Quality on Logging Jobs in Vermont*, August 1987, available from the Department of Forests, Parks, and Recreation. These BMPs have the force of law under the Vermont Water Pollution Control Act. A program of technical training (Sec. 5.2.4 below) is provided to landowners or loggers by Department foresters, consulting and industrial foresters, the University Extension System, and the Vermont Forest Products Association (VFPA).

Vermont does not have staff devoted to BMP inspections. Site visits are made in response to complaints or observations of water quality problems made by Department staff as they pursue other duties in the field. An informal estimate suggests that there are about 1000 large and small contractors in the state. Usually there are about 40 to 50 water quality complaints per year that turn

out to be legitimate after a field visit. Vermont tracks program activity carefully (Figure 4.4). The most commonly encountered sources of problems are failed stream crossings and brush left in streams. When inspections are conducted, the first priority is to seek to bring the operation into compliance and to do what is reasonable to repair the damage done, by removing slash from a stream, for example.

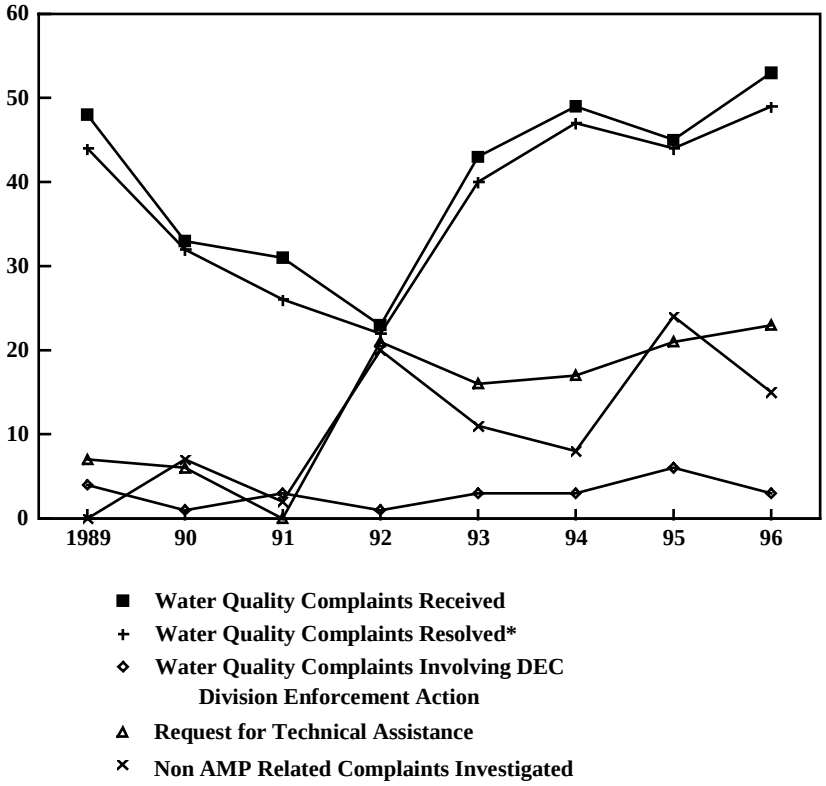


**Figure 4.4.** Summary of AMP Technical Advisory Team Activity, 1989 to 1996 (source: G. Sabourin, pers. comm.)

### 4.11.4 *Substate Programs*

None.

### 4.11.5 *Instruction and Education*

Education programs for loggers have been developed that include a workshop on the application of AMPs. Successful participants receive a certificate upon completion, although it is not an official certification program.

Training efforts are conducted by the LEAP program (Loggers Education to Advance Professionalism), a cooperative venture of public and private agencies coordinated by the state, and by the Professional Loggers Program. This effort was founded by the Vermont Forest Products Association. Both programs have trained several hundred operators over the years, and they maintain ongoing programs.

### 4.11.6 *Compliance*

Two recent studies provide some insight on the level of compliance with AMPs in Vermont.

At the request of the Forest Resources Advisory Committee, a 1996 assessment of 17 active and recently completed operations reviewed compliance with AMPs in Essex, Caledonia, and Orleans Counties in northeastern Vermont. Operations in seven towns were visited by an evaluation team. Permission was sought from landowners; none was denied. Compliance with the 24 recommended AMPs was evaluated by a grading system. Interesting points of the results included:

4. In 6864 feet of truck road examined, the AMP handbook called for 46 drainage structures; only 19 were installed. However, no instances of sediment discharge were observed where structures were omitted.
5. In three of six observations, protective strips for streams were in accordance with AMPs.
6. Silt fencing or hay bale dams were not used anywhere, but no instances of sediment discharge were attributed to failure to use such measures.
7. Several landings intruded into specified filter strips.
8. Skid trails totaling 4.5 miles were examined. According to AMPs these should have had 207 functioning drainage structures; yet only 80 were found. In some instances, there was an obvious reason for the absence of the structure. Whether absence of required structures caused discharges was considered inconclusive.
9. Sheet and gully erosion on the surface of inactive skid trails was found in the majority of the mileage evaluated.
10. At 9 of 17 stream crossings, natural conditions prevailed downstream; at the remaining 8, thinly coated streambed and coated rocks and alluvial fans were observed.
11. Protective filter strips were observed for almost 17,000 feet of streams. On 3200 feet, continuous canopy cover had not been maintained. In the streams observed, there were 24 entries of buffer strips, 38 stream crossings, 74 instances of logging debris in the streamcourse, and 9 instances of skidding in the stream.

The report supplied a number of useful recommendations for improvements (pp. 14ff) but drew no general conclusions from its observations, which is sensible given that informal and unreplicated observations may not support strong conclusions.

In November 1996, the Forest Resource Advisory Committee (FRAC 1996, p. 15) recommended that an outside contractor be retained to conduct an in-depth field study of AMP compliance and effectiveness. There is no indication yet that this will be done, however.

In an earlier assessment of Vermont's Acceptable Silvicultural Management Practices and Water Impacts (Brynn and Clausen 1991), the following results were reported:

> Seventy-eight recently completed (August 1987 - August 1988) timber harvesting operations in Vermont were evaluated for Acceptable Management Practice (AMP) compliance, soil erosion extent, and water quality impacts using a systematic, one-day examination of each site. Evaluations of water quality impacts and soil erosion were conducted on the portions of the transportation network and streams that could be most heavily affected by the timber harvesting operation. Increased stream sedimentation was observed on 46% of the operations with streams. Woody debris impacts occurred in 65% of the operations with

> streams. AMP compliance was over 90% for protective strip maintenance and stream avoidance, but soil erosion control practices on truck roads and skid trails commonly failed to meet AMP recommendations. Soil erosion was very limited on truck roads, skid trails, and log landings. Although the Vermont operations often only partially complied with the AMP's, minimal soil erosion and water quality impacts were observed.

According to the Report of AMP Technical Advisory Team Activities in Vermont:

> This report summarizes the results of the AMP technical advisory team responses to complaints received regarding discharges from logging operations throughout Vermont in 1991. The report also summarizes requests for technical assistance and any complaints received that did not turn out to be water quality violations. During the last year, one or more AMP technical advisory team members visited 31 logging operations to correct water quality problems. Voluntary compliance was successfully achieved by the technical advisory teams working with the logger in 26 cases. The number of water quality complaints against loggers has decreased over the past year. This drop can be attributed to a variety of factors including: increasing logger awareness of the AMPs, the ongoing efforts of the AMP technical advisory teams, and the weather conditions being somewhat drier than normal last summer. This was the first year that complaints have been followed up according to the procedures outlined in the Memorandum of Understanding between the Department of Forests, Parks, and Recreation and the Agency of Natural Resources Enforcement Division. While technical assistance under the MOU appears to be effectively curbing water quality problems on about 80% of the 31 logging operations in Vermont found to be in violation of the AMPs, a few problems with the technical team approach were evident this past year and should be rectified. (Report of the AMP Technical Advisory Team 1991)

#### 4.11.7 *Effectiveness*

See 1996 Field Review, discussed in previous section.

#### 4.11.8 *Current Research*

An extensive monitoring program concerned with a variety of ecological issues is underway (Wilmot and Scherbatskoy 1997). Under the aegis of the Forest Ecosystem Monitoring Project, a set of cutting treatments will be installed at Mt. Mansfield State Forest, and will be monitored for water and other ecosystem effects (Anon., n.d.). Ongoing work at Sleepers River includes basic hydrologic studies that are highly relevant, but cutting treatments are not included (Shanley, Sundquist, and Kendall 1995).

#### 4.11.9 *Current Policy Initiatives*

There are no specific actions at present. General discussion of recommendations of the Forest Resources Advisory Council will continue.

#### 4.11.10 *References*

AMP Technical Advisory Team. 1991. *Report of AMP Technical Advisory Team Activities in Vermont.*. Montpelier.

Anon. n.d. *VForEM forest ecosystem management demo project*. 4 pp. + app. (Plan for cut treatments at Mt. Mansfield).

Brynn, D.J., and Clausen, J.C. 1991. Postharvest assessment of Vermont's Acceptable Silvicultural Management Practices and Water Quality Impacts. *Northern Journal of Applied Forestry* 8(1991):140-144.

Forest Resources Advisory Council (FRAC), Assessment Working Group. 1996. *Report on field audit of AMP's for maintaining water quality on logging jobs in Vermont*. Montpelier. 16 pp.+ att.

Shanley, J.B., Sundquist, E.T., and Kendall, C. 1995. *Water, energy, and biogeochemical budget research at Sleepers River Research Watershed, Vermont*. USDA Forest Service. Open-file Report 94-475. 22 pp. Available from USGS Field Office, Montpelier.

University of Vermont (UV) School of Natural Resources. 1990. *Impact assessment of timber harvesting activity in Vermont.* Final report. 108 pp.

Vermont Department of Forests, Parks and Recreation (Dept. FP&R). 1997. *Intent to cut notification, emergency rules, standards, and procedures*. Waterbury. June 23.

Wilmot, S., and Scherbatskoy, T. (eds). 1997. *Vermont forest ecosystem monitoring*. 1995 Annual Report. Vermont Department of Forests, Parks, and Recreation. Waterbury. 302 pp.

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### 4.12 West Virginia

#### 4.12.1 *Assessment*

The West Virginia assessment identifies potential erosion from exposed areas of soil created during timber harvesting activities as a problem, which is preventable, by the application of BMPs (WVDNR 1987). The assessment report further states that soil erosion following forest fires is a serious problem. "Soil erosion as an aftermath of forest fires has been a serious problem for many decades…. It is believed that this problem creates more eroded material than does timber harvesting." According to USDA Forest Service data, West Virginia's average area burned from 1986 to 1990 was 127,000 acres, or 76% of the annual area burned for the entire 12-state region (P.M. Sever, pers. comm). Cutting activity in the state has been reviewed statistically by Birch et al. (1992). Condition of stream habitat from cumulative effects of past land uses is a significant emerging concern (Baumgras 1996, Anon. 1997, McComb et al. 1991).

#### 4.12.2 *Forest Practice Regulation*

A new Logging and Sediment Control Act (LSCA) was enacted by the West Virginia Legislature (Ch. 19, Art. 1B), and was effective in 1992. It requires mandatory notification; official certification of logger training in operations safety, posting of operations, first aid, and BMPs; a state license for loggers to operate; and reclamation of sites upon completion of logging. Notification forms are filed by loggers but are not signed by the landowner. Notification must occur between three days prior and three days after startup.

Administration of the LSCA is through area foresters and fire control staff. Roughly 3000 notifications are filed each year. The agency goal is to visit one operation by each logger each year. The state field staff can issue stop orders if an operator resists BMP compliance. Under such a "suspension order," the only activity permitted on a job is attaining compliance as directed. Referrals to the Department of Environmental Protection for enforcement are rare. The forestry agency is now sharing the services of an attorney in the Attorney General's Office. This should improve the resolution of legal issues or court cases that may arise.

The agency tracks the types of BMP violations that occur and uses this information on site visits and in training.

#### 4.12.3 *Nonpoint Source Program*

Authority to prevent water pollution from silvicultural activities is shared between the Division of Water Resources and the State Forestry Division, based on a cooperative MOA (Whipkey and Bennett 1989). The silvicultural NPS program is managed by the Forestry Division, with guidance provided by a Forest Water Quality Voluntary Compliance Committee. A state Silvicultural Erosion Control Plan outlines a voluntary program that includes specific BMPs; a schedule for implementing, monitoring, and program evaluation; development of an educational program; a

technical assistance program; and a specific reporting system, which is prepared by the State Forestry Division (WV Forestry Division 1989). The state's NPS program is to be revised in 1998.

BMPs are included within the state Silvicultural Erosion Control Plan, and are published as a pocket guide for forestry practitioners. The guide was revised in 1996 (WV Forestry Division 1996).

#### 4.12.4 *Substate Programs*

None.

#### 4.12.5 *Instruction and Education*

An Education and Training program is offered to loggers, landowners, and the general public. To help implement the new Logging Sediment Control Act, the Division is preparing a BMP training program for loggers, which will also fulfill the instruction and education task of the NPS program. Under the state's certification program, about 1600 of the state's loggers have been certified; a total of over 5000 have received training. Certificates must be renewed annually, and training must be updated every three years. An information bulletin has been prepared (Kochenderfer et al. n.d.).

#### 4.12.6 *Compliance*

The West Virginia Division of Forestry conducts a periodic survey to measure the use of silvicultural BMPs by the logging industry (WVDA 1987, Whipkey 1991). The most recent evaluation of compliance (1995-96) is reported by Egan and Rowe 1997 (Table 4.4). In their study, Egan and Rowe visited 95 logging operations around the state. They found evidence of sedimentation at 13% of these sites. Inadequate use of BMPs was identified as a cause at seven of these locations. Because the West Virginia BMPs had been revised in 1996, comparisons with previous studies were not possible for some items. For those practices for which comparisons were possible, compliance had improved since previous surveys. The survey's results indicated that compliance was variable, and that close-out seeding and mulching were often omitted.

On the basis of this survey, the authors offered several recommendations:

12. Landowners should share responsibility for compliance (currently they don't sign the notifications).
13. The entire forestry community should accelerate educational efforts.
14. The state's new Woodland Owners Association should play a major role.
15. Further compliance monitoring is critical.

#### 4.12.7 *Effectiveness*

An evaluation of the then existing (1979 to 1989) West Virginia logging BMPs was carried out at the Fernow Watershed and reported in detail by Kochenderfer, Edwards, and Wood (1997). The results showed that sediment returned to the previous level within three years. Simulations showed that over a 100-year time span, only 5% of sediment exported from the watershed would be due to logging. The authors concluded, "BMPs used in this study were effective in minimizing adverse impacts to soil and water resources" (Kochenderfer, Edwards, and Wood 1997, p. 207). The authors did use one BMP beyond those prescribed, which was pre-logging planning.

**Table 4.4.** West Virginia 1995-96 Compliance with BMPs

| Haul roads | Percent in Compliance | Skid roads | Percent in Compliance | Landings | Percent in Compliance |
|---|---|---|---|---|---|
| Grade <15% | 85% | Grade <20% | 77% | Outside filter strip | 79% |
| Cross drainage | 43% | Waterbars | 58% | Diverted approach roads | 85% |
| Outside filter strip | 54% | Smoothed | 78% | Smoothed | 81% |
| Gravel | 73% | Berm removed | 60% | Drained | 86% |
| Seeded/mulched | 37%/22% | Outside filter strip | 87% | Seeded/mulched | 70%/52% |
| | | Seeded/mulched | 55%/19% | | |

Source: Egan and Rowe 1997, pp. 12, 15, 17.

### 4.12.8 *Current Research*

Ongoing work at Fernow Watershed.

### 4.12.9 *Current Policy Initiatives*

None.

### 4.12.10 *References*

Anon. 1997. *Monongahela NF trends report, FYs 1987-96*. Elkins, WV. July 25, 1997. 24 pp.

Baumgras, J.E. 1996. Environmental concerns affecting forest operations on public lands in the Central Appalachians. In: C.R. Blinn and M.A. Thompson (eds.). *Planning and Implementing Forest Operations to Achieve Sustainable Forests*. USDA Forest Service, Northeastern Forest Experiment Station. , General Technical Report NC-186. pp. 40-46.

Birch, T.W., Gansner, D.A., Arner, S.L., and Widmann, R.H. 1992. Cutting activity on West Virginia timberlands. *Northern Journal of Applied Forestry*. 9(4):146-149.

Egan, A., and Rowe, J.P. 1997. *Compliance with West Virginia's silvicultural BMP., 1995-96*. Charleston. WVDOF-TR-97-1. 26 pp.

Kochenderfer, J.N. et al. n.d. *Woodlot management: an introduction to water in the forest*. West Virginia University, Extensive Service and USDA Forest Service; Northeastern Forest Experiment Station. 28 pp.

Kochenderfer, J.N., Edwards, P.J., and Wood, F. 1997. Hydrologic impacts of logging an Appalachian watershed using West Virginia BMPs. *Northern Journal of Applied Forestry*. 14(4):207-218.

McComb, W.C., et al. 1991. Planning for basin-level cumulative effects in the Appalachian coal field. In: Rodiek, J.E., and Bolens, E.G. (eds.). *Wildlife and Habitats in Management Landscapes*. Washington: Island Press. pp. 137-152.

West Virginia Department of Agriculture (WVDA). 1987. *1987 report on use of best management practices on logging operations in West Virginia*. 43 pp. +.

West Virginia Department of Natural Resources (WVDNR). 1989. *West Virginia nonpoint source assessment*. 90 pp.

West Virginia Forestry Division. 1989. *Soil erosion and water siltation*. 26 pp.

———. 1996. *BMP guidelines for controlling soil erosion and water siltation from logging operations in W. Virginia*. Charleston. WVDOF-TR-96-3. 29 pp.

Whipkey, R.D. 1991. *An evaluation of the use and effectiveness of best management practices to control nonpoint sediment from logging operations in West Virginia*. West Virginia Division of Forestry Publication WVDOF 91-3. 45 pp.

Whipkey, R.D., and Bennett, L.B. (eds.). 1989. *West Virginia silvicultural water quality management plan*. West Virginia Division of Forestry Technical Report 89-6. 97 pp.

#### 4.12.11 *Contacts*

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#### 4.12.12 *Websites with Local Information*

http://www.state.wv.us

## 5.0 REGIONAL PROGRAMS

### 5.1 Chesapeake Bay Restoration and Protection Program

On December 9, 1983, the Commonwealths of Pennsylvania and Virginia, the State of Maryland, the District of Columbia, the Chesapeake Bay Commission, and the USEPA pledged to restore and protect the Chesapeake Bay. This precedent-setting commitment, known as the Chesapeake Bay

Agreement of 1983, called for the preparation and implementation of coordinated plans to improve and protect the water quality and the living resources of the Chesapeake Bay. The Chesapeake Bay Restoration and Protection Plan (USEPA 1985) describes the federal and state strategies and programs which are to be implemented to meet the objectives of the project. For a useful overview, see Horton and Eichbaum (1991); USEPA (1995b); and Cooksey and Todd (1996).

After recognizing the effects of accelerated nutrient impacts on the bay, and generally including silvicultural sources as part of the problem, the plan sets forth the task of reducing the levels of nutrients and other conventional pollutants in runoff from agricultural and forested lands as one of several objectives. The plan identifies specific actions to be undertaken by the various jurisdictions. The Commonwealth of Pennsylvania is expected to implement a forestry program, and the State of Maryland is expected to develop BMPs for nutrient runoff control and landowner assistance programs. In the mid 1990s, the three states committed to establishing 2100 miles of new stream protection forest buffers in high-priority locations over 15 years.

Progress in meeting the goals and objectives of the Chesapeake restoration plan is reported in the recent draft *Progress Report of the Baywide Nutrient Reduction Re-evaluation* (Chesapeake Bay Program 1992). This report provides a review of pollution sources affecting the bay, noting that NPS discharges of nitrogen and phosphorus account for the largest part of the bay's pollution problems. On a baywide basis, it is reported that agricultural sources are dominant, followed by forest and urban sources. In commenting on the success of actions called for in the Restoration and Protection Plan, the report states that baywide nutrient reduction efforts have not invested heavily in the control of nutrients from forests, since forests represent the least polluting land use in the watershed. This re-evaluation indicated the need to continue implementing a variety of nutrient reduction strategies, which will be fine-tuned and focused on managing nutrient systems within the bay's watershed.

The United States Forest Service maintains an office with the Chesapeake Bay Program. This office coordinates forestry activities under the Program. One of its activities was a review of tracking accomplishments in pollution reduction via BMPs. The result was that little formal action in tracking accomplishments could be found at the state level (Chesapeake Bay Program 1996a).

State NPS Section 319 water quality programs in Maryland, and to a lesser extent in Pennsylvania, are an integral part of the strategies designed to reduce nutrient discharges to the bay. In all three states, increased emphasis is being placed on planting streamside buffer strips in agricultural areas. The program has announced a goal of planting 2100 stream miles of buffers, mostly on nonforestland (Chesapeake Bay Program 1993, 1996b).

### 5.1.1 *Contacts*

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Chesapeake Bay Program
web: http://www.epa.gov/r3chespk

### 5.2 Corps of Engineers

Under Section 404 of the Clean Water Act, the Corps has jurisdiction over alterations and filling in the waters of the United States, which has been interpreted by courts to include virtually all of the nation's surface water and the associated wetlands (see description in USEPA 1995a, p. 36 ff). Under Nationwide General Permit No. 26, certain limited activities generally associated with forest management were allowed under Permit by Rule. That is, activities complying with the permit's provisions did not need a special permit. In the future, arrangements will be made by Corps Districts with states for permitting of such activities under state-by-state Programmatic General Permits (PGPs) administered through state agencies or tribes. These are to be developed through the individual district offices, several of which have jurisdiction in the Northeast. There is no centralized way to track the status and implementation of this revision process.

#### 5.2.1 *Contacts*

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### 5.3 Coastal Zone Nonpoint Pollution Control Program

As part of the Coastal Zone Management Act (CZMA) Reauthorization Amendments of 1990, Congress enacted a new Section 6217 titled "Protecting Coastal Waters." This provision requires states with approved coastal zone management programs to develop and implement coastal nonpoint pollution control programs. These are programs to control nonpoint sources of pollution that affect coastal water quality. The state programs must be approved by both the National Oceanic and Atmospheric Administration (NOAA) and the Environmental Protection Agency (EPA). Once approved, the programs will be implemented through changes to the state nonpoint source pollution programs approved by EPA under Section 319 of the Clean Water Act and through changes to the state coastal zone management program approved by NOAA under Section 306 of the CZMA. States that fail to submit an approvable coastal nonpoint program face reductions in federal funds awarded under both Acts. In 1995, the CZM office provided additional flexibility to the states in implementing these requirements. Briefly, states were permitted to employ voluntary measures such as BMPs as long as "backup authorities" existed to deal with noncompliance.

Management measures guidance (US EPA 1993) addresses five source categories of nonpoint pollution: agriculture, silviculture, urban, marinas, and hydromodification. Proposed management measures related to forestry activities are shown in Table 5.1. The guidance publication describes the form and function of forestry management measures, and provides an estimate of the effectiveness of each measure in reducing pollution. A cost estimate for each measure is also

included in the report, but the sources of these figures are very tentative and site specific. Table 5.1 provides a list of EPA's proposed management measures.

**Table 5.1.** Proposed EPA Forestry Management Measures to Control Water Pollution, Coastal Zone Management Program

| Management Measure | |
|---|---|
| 1 | Streamside Special Management Areas |
| 2 | Wetland Special Management Areas |
| 3 | Transportation System Planning and Design |
| 4 | Transportation System Construction/Reconstruction |
| 5 | Road Management |
| 6 | Timber Harvest Planning |
| 7 | Landings and Groundskidding of Logs |
| 8 | Landings and Cable Yarding |
| 9 | Mechanical Site Preparation |
| 10 | Prescribed Fire |
| 11 | Mechanical Tree Planting |
| 12 | Revegetation of Disturbed Areas |
| 13 | Stream Protection for Pest. And Fert. Proj. |
| 14 | Petroleum Products Pollution Prevention |

Source: USEPA 1993. *Proposed guidance specifying management measures for sources of nonpoint pollution in coastal waters*.

State agencies are developing implementation plans with EPA and CZM offices. There are some serious jurisdictional and program overlaps and conflicts that need to be worked out (Dave Keeley, Maine State Planning Office, pers comm). The process is not yet complete for the region. Some states have effectively made the case that forestry does not need to be covered under their CZM programs.

### 5.4 National Forest Nonpoint Source Program

The Federal Water Pollution Control Acts (1972, 1977, and 1987) place the primary responsibility for water quality with the states. The Clean Water Act of 1977, however, requires federal agencies, including the USDA Forest Service, to comply with all federal, state, inter-state, and local water quality control requirements (Putnam, n.d.). This is usually implemented through MOUs between the forests and the state agencies. Further, the National Forest Management Act and regulations mandate water quality protection.

The Forest Service has developed a program for nonpoint source control based on BMPs supported by specific standards and guidelines. The program includes a process for designing site-specific BMPs to protect identified beneficial uses, compliance monitoring to ensure implementation of identified practices, effectiveness monitoring to ensure that practices yield expected results, and further adjustment of practices where necessary.

Water pollution control programs in the National Forests are implemented and enforced through timber sale contract provisions. Each timber sale contract incorporates the practices and standards determined to be needed on a site-by-site basis, consistent with Forest Plan requirements. A forester for the Forest Service ensures compliance with all contract requirements. Active operations are visited at least once a week, and as often as three times a week. A postharvest inspection is carried out to assure final compliance before the performance bond is released, and a one-year inspection is conducted to assure effectiveness of in-place practices.

In addition, the Forests conduct evaluation and monitoring inspections on a sample of timber sales to ensure that District staff is implementing BMPs, standards, and guidelines. These are detailed field inspections, and are often reported in annual Evaluation and Monitoring Reports for each Forest.

There are four major National Forests in the region, the White Mountain (New Hampshire and Maine), the Green Mountain/Finger Lakes (Vermont and New York), the Allegheny (northwestern Pennsylvania), and the Monongahela (West Virginia). In most of these Forests, federal ownership is not contiguous. National Forest managers adopt BMPs in the form of "standards and guidelines" that must be met in road building, harvesting, and other projects implementing the plans. Additionally, annual monitoring efforts determine compliance with prescribed BMPs and assess changes in stream conditions. An article by Whitman (1989) contains much useful administrative and policy information, though it deals with western issues.

Most Forests have a watershed expert or hydrologist on their staff for this work, but regular monitoring of water quality is not common. All four of the Forests listed were contacted for this report. Water quality issues have played a role in recent litigation on several eastern National Forests, so an increased focus on this issue can be expected.

### 5.4.1 *Allegheny National Forest (ANF)*

The ANF includes 513,000 acres of federal land in northwestern Pennsylvania. Between 1870 and 1920, this region's forests were heavily cut and burned. Local effects of coal mining and oil and gas extraction have also left their marks on the land. In this hilly terrain, high quality coldwater fisheries are an important management consideration. ANF's watershed specialist monitors projects for BMP compliance and effectiveness, and results are occasionally reported in Monitoring Reports. Existing roads have been a concern. It was found that streamside filter strips, in themselves, are not always adequate to prevent the entry of silt into the water. The reviews have led to a number of improvements in road construction BMPs (ANF 1991, p. 39).

### 5.4.2 *Monongahela National Forest (MNF)*

West Virginia's 896,000-acre MNF contains "about 50% of the State of West Virginia's cold water fishery and 90% of the self-sustaining wild trout fishery" (Myers 1997). MNF staff estimates that 60% or more of the stream mileage is impaired when judged by embedded sediment. This is the result of decades of past management and land use. In preparation for Plan revision, the Forest has established working groups to review standards and guidelines for roads and riparian management and alternative logging methods.

### 5.4.3 *White Mountain National Forest (WMNF) and Green Mountain National Forest (GMNF)*

These two forests include rugged terrain in northern New England. Extensive areas are not scheduled for timber harvesting under current plans, and their timber programs have dwindled to the point that they are now managed from a single office. Watershed specialists conduct site-to-site

monitoring, but there is no ongoing water quality monitoring related to logging activities. No site-specific studies are available. On the GMNF, specialist Nancy Burk has a dataset on effectiveness monitoring of standards and guidelines, and anticipates completing a report in 1998. The WMNF includes 742,000 acres of federal land, and the GMNF includes 359,000 acres.

### 5.4.4 *References*

Allegheny National Forest. *Monitoring and evaluation report*. 1995. Processed. Wayne, PA.

Myers, C.L. 1997. *Monongahela NF trends report for FYs 1987-96*. Elkins, WV. 24 pp. + att.

Whitman, R. 1989. Clean water or multiple use? BMP's for water quality control in the National Forests. *Ecological Law Quarterly*. 16: 909-966.

### 5.4.5 *Contacts*

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## 5.5 Total Maximum Daily Load (TMDL) Litigation

The Clean Water Act requires assessments and additional pollution controls for streams whose quality does not meet beneficial use objectives under Sec. 303(d). Total Maximum Daily Loads (TMDLs) of specific pollutants are calculated and allocated. On this basis, point source dischargers or nonpoint sources may be required to cut back discharges by amounts greater than would be required by Best Available Control Technology (BACT) or BMPs. In 1996, EPA national guidance on TMDLs was revised.

In several northeastern states, court orders or litigation are underway to compel states to schedule and implement TMDLs more aggressively (Table 5.2). As part of their assessment process, most states already develop lists of TMDL priority stream reaches and waterways.

Adoption and implementation of TMDLs will occur waterway-by-waterway over many years. As yet, no instances in the Northeast have arisen in which logging-related discharges have been a major concern. One source suggests that this will be the case for several years (T. Henry, EPA R-III, pers. comm.).

**Table 5.2.** Total Maximum Daily Load Litigation Status in the Northeast, 1998

| | |
|---|---|
| Court Orders in Place (Consent Decree) | |
| Pennsylvania | 1997 |
| West Virginia | 1997 |
| Delaware | 1997 |
| | |
| Litigation Filed | |
| New York | |
| New Jersey | |
| Maryland | |

Source: USEPA Website: http://www.epa.gov/owow/tmdl/.

As court orders are filed in other states and implementation proceeds, it will be possible to see what implications the TMDL process may have for forestry water quality programs in this region.

### 5.5.1 *Sources*

EPA's website contains policies and status of litigation: http://www.epa.gov/owow/tmdl.

## 6.0 REGIONAL COMPARATIVE OVERVIEW OF STATE NONPOINT SOURCE PROGRAMS FOR FORESTRY

This section consists of tables comparing program activity across the region's states. These supply a broad overview of regionwide activity. It also offers commentary on general regional trends and issues.

### 6.1 Nature and Extent of Nonpoint Source Pollution from Silvicultural Activities

Silvicultural activities as a source of NPS pollution are generally rated as minor to non-existent across the region (Table 6.1). Most states recognize the potential for water quality impairment from timber harvesting, especially soil erosion and sedimentation caused by roads and stream crossings. The states repeatedly report a serious lack of monitoring information, and generally fall back on widely accepted generalizations about the impact of timber harvesting on water quality. In states where forestry-related water quality problems have been studied in detail (Maine, Vermont, Massachusetts, New York, and West Virginia), results show that erosion and sedimentation do occur from a significant proportion of logging jobs conducted near surface waters. Studies and experience also show that when relatively simple, cost-effective BMPs are applied, the occurrence or severity of erosion and sedimentation is significantly reduced.

The nature and extent of silvicultural sources of water pollution in the region are not well quantified. However, NPS program managers consider forestry sources to have a relatively low impact. This low level of concern about potential impacts from forest practices means that limited water quality monitoring is done to assess conditions, trends, and potential impacts.

In comparison with other nonpoint sources of water pollution, state assessment reports consistently find that silvicultural source impacts are limited in spatial and temporal effects. In a number of states in this region, impacts from acid mine drainage, farming, roads, grazing, and development are considered far more significant than those from forest uses.

Funds and staff available for these programs are limited, and have been cut back due to tight budgets. State officials attempt to meet the highest priority needs, but recognize that information and education, enforcement, and monitoring are not reaching every landowner or logging operator. Reporting by the public is the general means of learning of problems or potential violations.

**Table 6.1.** State Assessments of Nonpoint Source Pollution from Silviculture

| State | Amount Impacted[1] | Assessment Comments | Assessment Studies |
|---|---|---|---|
| ME | 97 miles | minor to moderate | Briggs (1997) |
| NH | | minor statewide, moderate in some watersheds | |
| VT | 45 miles | limited data, underreporting occurs | UVM Timber Harvesting Impact Study. Authors report increased sediment loads in nearly one-third of the operations that involved a lake, stream, or wetland. Further, over one-half of the operations with stream crossings exhibited sediment impacts. |
| | | potential problem | Brynn and Clausen report increased stream sedimentation on 46% of recently completed operations involving streams. |
| | | | In its annual report on the activities of the AMP Technical Advisory Team, Vermont Department of Forests reports 31 occurrences of logging-related water quality problems. Total logging activity is not reported. |
| MA | | limited data | Thompson and Kyker-Snowman report results of a very limited survey of active and recently completed logging jobs. They found evidence of erosion and sedimentation on all five active sites, and on three of six inactive sites. |
| | | | Final GEIR. Erosion from logging was reported on 120 (23%) of 530 completed harvesting operations covered by the State Cutting Practices Act. |
| WV | | potential from T.H. serious after fires | Of 95 sites, 13% had evidence of sedimentation (Egan and Rowe 1997). |
| RI | | not considered to be a problem; recognize as a potential threat | |
| PA | | lack of data on occurrence or causes | |
| NY | | localized, short duration | King. Overall, erosion was evident from the transportation system on 42% of logging operations studied. |
| CT | | low priority | |
| NJ | | not considered to be a problem | |
| DE | | small concern | |
| MD | | low priority | Forestry is not mentioned in the Assessment. |

[1] Amount of documented surface water impacted.

## 6.2 Program Structure

The CWA requires states to develop clean water strategies that will be effective in maintaining and preventing degradation in water quality. All of the states in the region that have established a forestry component (Table 6.2) in their NPS management programs rely on a strategy of cooperation and coordination between the Environmental Protection Agency and established forestry programs, with participation from other appropriate agencies and interests (Table 6.2). They rely on the existing infrastructure of forestry interests, government programs, and related laws to deliver information and education programs, to develop and publicize BMPs, and to provide guidance and assistance.

In most cases, the state forestry agency has the lead in delivering silvicultural NPS programs. Some states, like West Virginia, develop formal silvicultural erosion control program plans. Many states with active programs use a program advisory committee to help develop and oversee program activities. In the case of New York and Vermont, the programs are closely tied to private forestry groups who take an active role in education, technical assistance, and enforcement.

The designated state NPS program agency, which is usually the Environmental Protection Agency, retains the authority to enforce water quality protection laws and regulations. In states with Forest Practice Laws or other forestry laws, the state forestry agency is responsible for enforcement of forestry laws, but water quality protection regulations often are developed under the authority of related laws and the jurisdiction of other state agencies or municipalities. Overall, there has been a general tendency in the region for states to increase their reliance on regulatory approaches through establishment of new laws that include forestry activities even if forestry is not the prime focus of a water quality problem.

Involvement of university and extension programs, often cooperating with industry groups, has increased as logger training has become more formalized and extensive.

**Table 6.2.** Silvicultural Nonpoint Source Program Implementation

| | | | State Laws | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| State | Reg. or Vol.[1] | DEP | FPA[2] | E&S or stream crossing | Wet-lands | Forestry agency | Local agency or SWCD[3] | Logging cert. or agency | Logging cert. or licensing | SFI[4] |
| ME | R | APE[5] | X | X | X | BMPs; insp, I&E[6] | Shoreland Zone | LURC | Vol | Y |
| NH | R | APE | | | X | BMPs; insp, I&E | | | Vol | Y |
| VT | R | APE | X | | | BMPs; insp, I&E | | | Vol | Y |
| MA | R | APE | X | | X | BMPs; insp, I&E | Wetlands Comm. | | Lic | |
| WV | V | APE | | LSC Act | | BMPs; insp, I&E | | | Lic | |

(Continued on next page. See notes at end of table.)

**Table 6.2.** Continued

| State | Reg. or Vol.[1] | DEP | State Laws: FPA[2] | State Laws: E&S or stream crossing | State Laws: Wet-lands | Forestry agency | Local agency or SWCD[3] | Logging cert. or agency | Logging cert. or licensing | SFI[4] |
|---|---|---|---|---|---|---|---|---|---|---|
| RI | V | APE | | | X | BMPs; insp, I&E | | | Cert | |
| PA | R | APE | | X | X | BMPs; insp, I&E | County CDs | Ches. Bay[7] | Vol | Y |
| NY | V | APE | | X | X | BMPs; insp, I&E | | APA | | Y |
| CT | R | APE | X | | X | BMPs; insp, I&E | Wetlands Comm. | | Cert | |
| NJ | V | APE | | | X | BMPs; insp, I&E | | Pinelands | | |
| DE | R | APE | | X | | BMPs; insp, I&E | | Ches. Bay | | |
| MD | R | APE | STL[8] | X | | BMPs; insp, I&E | SCDsR | Ches. Bay | Cert | Y |

[1] Regulatory or voluntary.
[2] FPA = Forest Practices Act.
[3] SWCD = Soil and Water Conservation District.
[4] SFI = AF&PA Sustainable Forestry Initiative.
[5] Assessment, Planning, Enforcement.
[6] Best Management Practices; Inspection, information, and education.
[7] Non-regulatory.
[8] Seed Tree Law.
Note: other programs and rules are in effect in some states.

## 6.3 American Forest and Paper Association (AF&PA): Sustainable Forestry Initiative

In 1995, the American Forest and Paper Association (AF&PA) adopted the Sustainable Forestry Initiative (SFI) to promote and publicize improved management by its member companies. Implementation is through state committees that prepare guidelines for management practices and reporting. Progress is reviewed by a national advisory committee. Committees have been formed in all the northeastern states except Delaware, New Jersey, and southern New England, areas containing little industry land. Not all industrial owners are AF&PA members (AF&PA 1996a, 1996b).

The SFI commits members to follow twelve major "principles" of sustainable forestry, one of which involves protecting water quality. In a number of instances (e.g., Champion International in New Hampshire), SFI members have adopted BMPs more stringent than existing requirements. Several companies unwilling to adopt the SFI goals were dropped from the organization.

## 6.4 Administration of Best Management Practices Implementation Programs: An Overview

Administration refers to the ways in which forestry and environmental agencies oversee the implementation and enforcement of water quality BMPs. Strictly speaking, this process should not be described as BMP enforcement, as BMPs are considered voluntary by the agencies in most states. Avoidance of pollution is not voluntary. Inspections of logging operations may be conducted if they

are needed for other laws, for example, Maine's Forest Practices Act for enforcing fire control rules, or for following up on wetlands or stream crossing permits. Failure to install a recommended BMP in itself is generally not considered a legal violation. In some states and in certain situations, violations of BMPs may violate other laws concerning wetlands, stream crossings, erosion control, water supply protection, or streamside or lakeside filter strips. In such cases, an omission of a BMP is not the infraction—the violation of the other laws is. Where BMPs are considered voluntary, planned inspections of operations to detect compliance with them are not usually performed except as a byproduct of another needed visit, or in the unusual instances where operators are known to repeatedly defy the rules.

In most states, complaints are relied upon as the principal method of detecting water quality impacts. When a forestry agency detects or receives word of an actual violation, whether by complaint or from its own observations, the violation is checked onsite. Generally, efforts are first made to bring operations into compliance and repair existing damage, if possible. Most forestry agencies do not have on-the-spot cease and desist authority for water quality violations. When enforcement action is found to be warranted, the case is referred to the environmental regulatory agency for further action. In some states, notification requirements may enable forestry officials to identify active operations. This aids inspection and administration. Where specific permits are required from an environmental agency, that agency has a record that can be used to support spot checks for enforcement. Even where notification requirements exist, staff may not be available for inspections.

Enforcement action is triggered when a discharge of sediment into state waters is detected or when some other legal violation occurs. When a discharge is detected, the proper installation and maintenance of BMPs may suffice to shield a landowner and operator from liability for penalties.

Administration is complicated by the number of actors involved (Table 6.3). The numbers of landowners and loggers involved in logging activities is enormous—almost 40,000 each year across the region. The scale of the administrative task for water quality BMPs is daunting, considering the large number of actors involved and the remoteness of much of the activity (Table 6.4).

**Table 6.3.** Schematic BMP Administration Flow Chart for Individual Harvest[1]

| Activity | Land owner | Forester/ Consultant | Logger | Forestry agency | Environ. Agency | Other WQ agency |
|---|---|---|---|---|---|---|
| Plan cut | X | X | X | | | |
| Notify | X | | | X | | X |
| Technical advice | | X | | X | | X |
| Conduct operations | | X | X | | | |
| Inspect or respond to complaint | | | | X | | X |
| Violation referred | | | | X | | X |
| Enforcement action | | X | | | X | X |
| Put to bed | X | X | X | | | |

1 Details may vary from state to state.

**Table 6.4.** BMP Administration: Size of Task

| State | Acreage[1] (1000) | Private Ownership[2] | Operations[3] |
|---|---|---|---|
| Maine | 17,060 | n/a by state | 8,000 |
| New Hampshire | 4,144 | n/a by state | 5,000 |
| Vermont | 3,993 | n/a by state | 2,000 |
| Massachusetts | 2,529 | n/a by state | 800 |
| Connecticut | 1,553 | n/a by state | 600 |
| Rhode Island | 338 | n/a by state | 200 |
| SUBTOTAL NEW ENGLAND | 29,617 | 74,100 | 16,600 |
| New York | 14,367 | n/a by state | 6,000 |
| Pennsylvania | 12,508 | n/a by state | 12,000 |
| West Virginia | 10,745 | n/a by state | n/a |
| Maryland | 2,272 | n/a by state | 2,000 |
| Delaware | 346 | n/a by state | 150 |
| New Jersey | 1,401 | n/a by state | 240 |
| SUBTOTAL MID-ATLANTIC | 41,640 | 221,000 | 20,390 |
| ALL STATES | 71,257 | 295,100 | 36,990 |

[1] Private timberland acreage, 1994.
[2] Estimated number of private landowners of 10 acres or more, 1994.
[3] Estimated number of logging operations.
Sources: Birch 1996, pp. 12, 54,66; numbers of operations based on author interviews with state officials and author estimates.
Note: including owners of more than 1 acre, total is 2.2 million owners (Birch, p.12); the term "timberland" is used here in the FIA sense.

## 6.5 Information and Education Programs

Every state relies on information and education programs. Most states conduct initial workshops and training sessions to explain published BMPs. Sometimes these programs are one-time sessions to explain legal requirements and applicability of BMPs; at times they incorporate a broader array of silvicultural and harvesting practices.

As public programs or private sector initiatives, some states are developing ongoing logger training and certification programs designed to improve logging services to customers, enhance logger profitability, and ensure compliance with applicable laws. Training on BMPs to protect water quality is included in these programs. An excellent summary on logger training was issued by the American Pulpwood Association (1998).

States with active forestry agencies generally have in-place mechanisms and ongoing programs to deliver information and educational programs to landowners, forest resource professionals, and loggers. Water quality protection programs are generally offered periodically as needed. As is true of other forestry and agricultural extension programs, the I&E task is never completed because of turnover among landowners and loggers.

## 6.6 Best Management Practices (BMPs)

The CWA requires the development and application of BMPs (see Table 4.1) as the principal method for controlling nonpoint sources of water pollution. BMPs, or their equivalent, have been developed in most states. BMPs often must be developed in an absence of locally relevant research and experience, using regional guidelines or results extrapolations from other areas. Silvicultural BMPs may be published as guidelines and included in information and education programs designed to promote sound forestry in non-regulatory programs, such as in New York and West Virginia. BMPs may be incorporated into related laws such as wetlands protection (Massachusetts, New Hampshire), erosion and sedimentation laws (Maryland, Connecticut, Delaware, Pennsylvania), water quality protection regulations (Vermont, Maine), or land use regulations in regional and municipal settings (Maine, New Hampshire, New Jersey, Connecticut, Maryland). Alternatively, the potential water quality impacts of timber harvesting may be included as a focus of special planning and management regions like the Chesapeake Bay Program and the new EPA/NOAA Coastal Zone Management Act program.

Some approaches that deserve wider use are the inclusion of BMPs in standard timber sale contracts and a BMP for precut planning, which is the most effective prevention measure. As intended here, planning refers to the practical consideration of details such as location and orientation of trails, landings, and roads within the areas to be cut. Also, suitable BMPs should be developed to cover long-term road, culvert, and bridge maintenance, since research shows that ongoing siltation from existing road systems can be a significant concern.

## 6.7 Regulatory vs. Voluntary Programs

Classifying a state program as regulatory or voluntary is not always simple. Generally, for the purposes of this analysis a state is considered to have a regulatory program if BMPs to protect water quality have the force of law, either by direct application as regulations or by incorporation in related laws or regulations. An example would be cases where certification of adherence to BMPs is included as part of a preharvest notification under a tax law, wetlands protection program, or erosion and sedimentation law.

A state is considered to have a voluntary program if BMPs designed to protect water quality are not legally binding or are non-existent, even though laws and regulations exist that apply to other forestry activities, such as seed tree laws, regeneration regulations, or roadside cutting limitations. Using these definitions, programs in eight of the twelve states in the study region are classified as regulatory (Table 6.2). For another definition, see Essig (1991).

Under a program coordination/cooperation strategy, BMPs are applied in a variety of ways, depending on the unique characteristics and administrative organization of each state. Given these mixed implementation programs, it is difficult to classify a state silvicultural NPS program as regulatory or not.

Forestry agencies and landowner groups in some states are concerned about a phenomenon of "regulatory creep" that occurs once BMPs are published (e.g., ESFPA 1997). In at least one state, the environmental agency has declared that previously voluntary BMPs are now mandatory, and has required their use by regulation. In other states, municipal harvesting ordinances, often quickly drafted, may adopt BMPs as required practices and not as recommendations or voluntary guidelines.

## 6.8 "Bad Actor" Provisions

Enforcement strategies for dealing with violators, the "bad actor" provisions, vary from state to state. In most states, the primary objective is to obtain remediation and assurances of future

compliance. Administrative settlements, at times involving fines, are sought in the majority of instances when the forestry agencies fail to achieve cooperation (e.g., Vermont reports three cases in 1991 referred by state foresters for official enforcement action). In extreme cases, court action is necessary.

In states developing formal logger certification programs (Connecticut, Maryland, and West Virginia), an enforcement program can revoke a logger's license to practice.

### 6.9 Compliance

Studies of compliance with forestry BMPs and other pertinent regulations have been conducted and reported in several states in the region (Table 6.5).

Generally, satisfactory compliance with stream or surface water setbacks is observed, but compliance with erosion control provisions on skid roads and other areas with disturbed soil is lower. It is relatively easy to physically avoid a surface water feature, which accounts for good compliance with buffer standards. Loggers may need more encouragement to build and maintain erosion control structures and to re-seed completed operations. Generally, compliance is best for practices that are easily checked on the ground and that do not inflate loggers' costs or worktime per unit of output. Application and maintenance of BMPs is likely to be affected by the degree of landowner and professional involvement in timber sales.

Some of these results are not encouraging, yet several state contacts report marked improvement when aggressive and targeted information and education programs are conducted. Anecdotes suggest that a few dramatic enforcement actions can have a salutary effect. When analyzing the level of compliance with BMPs there is some uncertainty as to the correct standard for comparison.

### 6.10 Effectiveness

State surveys turned up two recent studies of the effectiveness of BMPs (Table 6.6). Lynch and Corbett reported on the results of 15 years of stream monitoring following a timber harvest on the Leading Ridge Research Forest in central Pennsylvania. They report that over all, BMPs employed were "very effective" in preventing serious deterioration of stream water quality, although elevated discharges of nitrates, potassium, and turbidity were measured for as long as nine years following harvesting. These results compare well with similar results reported in the literature over the past 20 years. Studies reported from Maine, Vermont, and West Virginia support the general view that relatively inexpensive BMPs are effective in controlling runoff and erosion from logging jobs and preventing discharges to protected surface waters (LURC 1979; UV 1990; Kochenderfer, Edwards, and Wood 1997). Interestingly, no current compendium of research results evaluating the effectiveness of specific practices in the region was found (however, see Belt, O'Laughlin, and Merrill 1992). Studies tend to evaluate watershed effects, not the cost-effectiveness of a specific practice in a particular location. Nor is there much work on the cost-effectiveness of one practice vs. another in a specific or general application. Another summary of the effectiveness of established BMPs in preventing soil erosion and sedimentation is contained in the Massachusetts Draft General Environmental Impact Report (GEIR). Based on survey data and general experience, the GEIR states that the use of BMPs has been shown to be effective in controlling erosion. In interviews, experienced forest hydrologists supported the view that properly installed BMPs will minimize water quality impacts of logging operations, speed recovery, and function effectively except in extreme rainfall or flooding events (also see SAF 1995).

**Table 6.5.** Silvicultural Nonpoint Source Program Compliance and Effectiveness

| State | Compliance/Enforcement Studies | Effectiveness Studies |
|---|---|---|
| ME | Briggs (1997) reported generally good compliance. | Some observations are in Briggs 1997. Older LURC studies have small samples. |
| VT | Brynn and Clausen reported over 90% compliance with buffer strips and streams avoidance, but erosion control practices on truck roads and skid trails commonly failed to meet AMP recommendations.<br>In 1991 the AMP Technical Advisory Team visited 31 logging jobs to correct water quality problems. Voluntary compliance with AMPs was achieved by the Technical Advisory Team working with the loggers in 26 cases. | A paired watershed study was initiated. |
| WV | The 1990 state survey of the use of BMPs measured marked improvements in keeping roads away from streams, but found poor compliance with the seeding of landings and skid roads, and with skid road maintenance and retirement.<br>Egan and Rowe (1997) found variable levels of compliance. | Kochenderfer et al. (1997) evaluated the effectiveness of various road and culvert construction practices on the Fernow Experimental Forest[1]. |
| PA | | Lynch and Corbett evaluated the results of fifteen years of streamflow and water quality data to determine the effectiveness of BMPs on the Leading Ridge Research Forest in central PA. Trieu and Arnold, n.d. |
| NY | King (1989) noted low level of compliance and little erosion. 40% of stream crossings showed erosion, and 42% of operations had erosion on transportation systems.<br>Briggs has a new compliance study underway. | |
| MA | MA final GEIR. Evasions of the Forest Cutting Practices Act are very minor, usually confined to operations at the BMP's border of regulatory thresholds. | Final GEIR. Application of established BMPs have been shown to be effective in controlling sedimentation. |
| MD | Koehn and Grizzel (1995) found varying but generally good levels of compliance. | A paired watershed study (Sugarloaf) is underway to test BMPs. |

[1] This work has led to a large list of publications. Contact the Parsons Timber and Watershed Laboratory for a list.

In addition to these two assessments, EPA attempted to consolidate an estimate of the effectiveness and costs of management measures proposed for forestry activities in its draft proposed guidance for the coastal zone NPS program (Section 6.6). These estimates of the effectiveness of BMPs are based on EPA's view of available information, and are not necessarily confirmed by research results. Nonetheless, these estimates tend to confirm experiences provided by various state-level contacts.

**Table 6.6.** Current and Planned Events (Except Information and Education), Northeastern States

| State | Activity | Status |
|---|---|---|
| ME | BMP demonstration project - Orono | under development |
| | Atlantic Salmon Initiative | ongoing |
| NH | Heavy cutting review | report 1998 |
| NY | Updated field guide for BMPs | 1998 |
| | Complete NPS plan | 1998 |
| | Field evaluation review of compliance | in progress |
| CT | Logger/forester certification | ongoing |
| | Plans to update BMP handbook | 1998 |
| WV | Revision of NPS program | 1998 |
| DE | Revised MOU on BMP administration | 1998 |
| | Enter Maryland Master Logger Program | |
| MD | Complete paired watershed study | 1998 |
| VT | Cutting treatments, Mt. Mansfield research site | 1998 |
| all states | Analysis and planning related to CZM/EPA management measures | ongoing |
| all states | Analysis and planning concerning wetlands designation procedures - Corps of Engineers 404 program | ongoing |
| 4 NFs | Revision of management plans | forthcoming |

### 6.11 Overview of Program Situation

The NPS management programs of this region went through difficult initial stages as agencies contended for program control, regulated groups resisted various provisions, and administrative procedures and BMPs were drafted. Though there is little evidence of severe water quality problems resulting from forestry operations, forest management is often swept into control programs developed to address construction or agricultural impacts. When this occurs, programs can be set back to an earlier stage of conflict and uncertainty.

In general, however, the NPS programs in this region have reached a level of administrative maturity. They have completed extensive programs of instruction and education, and for the most part regulated landowners and loggers are aware of the rules. Due to completion of initial instruction and education work and extreme budget shortfalls, staff commitments to the various NPS activities have shrunk.

The programs are now in a “maintenance” mode, trying to ensure that past progress can be retained. A significant challenge is posed by the steady turnover of landowners and loggers. This ensures a steady influx of people who may be unaware of the rules, or who may believe that they can be safely ignored.

States have been adding to their NPS program capabilities to deal with locally targeted priorities such as water quality in Chesapeake Bay, the Pinelands, or the Catskills. This suggests that there is a sense in some state legislatures that the general level of program activity and compliance is not

adequate when especially important resources are concerned. Another important development is the use of logger enhancement or certification programs. Three states (Connecticut, Maryland, and West Virginia) have programs designed to require a license for all loggers operating in their states. A condition of receiving a license will be to demonstrate knowledge of various regulations, including BMPs. In Maine, a Logger Certification Program has trained more than 1500 loggers in a variety of skills, but there is no legal requirement to become certified.

Finally, the states are preparing for program assessments and are continually making adjustments as their NPS programs are revised. All but one of the states are involved in responses to CZMA management mandates. New Corps General Permits are being developed, and in a few states TMDL allocations could become a factor at some time.

### 6.12 The Next Step in Improving Compliance

Surveys show that BMP compliance is not complete anywhere, even on public lands. The reasons for this situation are many, and are often poorly understood. It could be that some landowners and loggers are still unaware of the rules. Some BMPs are considered too costly, and some operators believe that the likelihood of being caught is low. Also, some operators or managers often judge that a specific practice is not needed in a given situation.

After about two decades of effort, it would seem that the easiest problems have been solved. The challenge of boosting BMP compliance beyond current levels will be more difficult. It will involve dealing with the more unruly and difficult operators and landowners, with more costly problems, and with operations in more remote areas. At a time when staff for instruction, education, and enforcement is already overloaded, this will be a daunting challenge. This points to a critical need for better training materials and outreach, better instruction, education, and enforcement systems, periodic field surveys of compliance, and better program administration. It may also suggest a need for improving the level of detail, clarity, and precision in BMP guidebooks and training materials. Programs such as the SFI and state-level logger training and certification programs are important ways to improve BMP implementation by placing a stronger industry commitment behind the programs. In addition, there may be a role for carefully designed and targeted tax incentives, cost sharing, or other incentives.

## 7.0 STATUS OF MONITORING AND RESEARCH

### 7.1 General Issues and Trends in the Northeast

#### 7.1.1 *Improved Assessment of Existing Knowledge*

Forest managers, planners, watershed specialists, and water quality officials can take advantage of a number of extensive and thorough literature reviews that have recently become available. These reviews differ in geographic and functional focus, but they provide a considerable improvement in the assessment of existing scientific information and increase the ease of locating information (Anon. 1979; Brown and Binkley 1994; Moring and Finlayson 1996; Kahl 1996; Hornbeck and Leak 1992; Hornbeck et al. 1993; Hornbeck et al. 1997; Hornbeck, Martin, and Eager 1997; Ice et al. 1997; National Acad. Sci. 1997; Comerford, Neary, and Mansell 1992). Major bibliographies covering work at Fernow and Hubbard Brook are valuable aids as well (Godwin et al. 1993; Stickney, Swift, and Swank 1994).

### 7.1.2 *Extreme Storm Events*

It has always been recognized that erosion and sedimentation events occur primarily during the most intense storms (Larson, Lindstrom, and Schumacher 1997). While datasets are readily available for weather stations, these are not located in headwater areas, so analyses of existing data may or may not be adequate for determining intensities for storms in forested areas. Headwater streams in steep, mountainous areas are likely to experience localized intense storms.

Two studies document storm intensities and their effects for the northeast. In work at Fernow Kochenderfer, Edwards and Wood (1997), found that storms causing bankfull streamflows occurred every 1.8 years, on average. Their results showed that over a rotation of a century including three entries, less than 5% of the sediment would come from forest management. They found that a single storm with a 47-year recurrence interval carried 35% of all the sediment removed from a monitored watershed in 11 years. They noted that the largest storms may flush sediment from the streambed because of their high capacity for carrying the sediment, while smaller storms deliver sediment to the channel and leave it there, where it alters fish habitat.

In work at Hubbard Brook, it was found that annual precipitation totals did not correlate closely with sedimentation. This was attributed to the effects of severe storms (Martin and Hornbeck 1994, p. 19). In these studies, it was also found that infrequent, intense storms remove most of the sediment (C.W. Martin, pers. comm.).

Researchers at both Fernow and Hubbard Brook concluded that properly installed BMPs will not eliminate all sediment moving into streams, but will maintain amounts within the general range of annual variability, except for the effects of extreme storm events that may occur shortly after road building and cutting.

The importance of extreme events has major implications for harvest planning and BMP implementation. BMPs that will withstand “normal” rainfall events might not withstand extreme storms. Yet intense storms are frequent enough to be considered “normal” for planning purposes. This fact may justify conservative practices in BMP installation and harvest planning and additional practices, especially in high-value watersheds or sensitive soil conditions. As Larson, Lindstrom, and Schumacher (1997, p. 93) commented concerning agriculture, “The risk of severe storms needs to be built into erosion control planning.” Unfortunately, the few studies of BMP effectiveness that have been conducted do not document the intensity of storm events that occurred in the area being studied during the period being evaluated. A useful innovation is the concept of a “diversion-proof crossing” (Hagens, Weaver, and Madej 1986).

A literature review by Pamela Edwards, USDA-FS, Northeastern Forest Experiment Station, Parsons, West Virginia, is planned for completion late in 1998.

### 7.1.3 *Infrequent Forest or Land Use Disturbances*

Watersheds of lower-order streams may be affected by forest disturbances such as wildfire, insect outbreaks, extensive windthrow, or other natural disturbances other than roads and cutting. An extreme case is the Mt. St. Helens eruption. Other examples more relevant to the East might include past mining and agricultural activities. Baseline conditions in streams may be affected for long periods by such local disturbances.

### 7.1.4 *Nutrients and Trace Elements*

Over the years, the importance of sedimentation and stream temperature has been thoroughly studied. Further, concern over soil nutrient balances has led to monitoring of various key nutrients

such as calcium, nitrogen, and potassium. Evolving scientific understanding of stream ecology and atmospheric chemistry has increased the number of issues that may need analysis. For example, Kahl (1996) points out that there is little information on how timber harvesting affects aluminum concentrations in streamwater. Research suggests that aluminum could be a concern for toxicity to fish and other organisms.

### 7.1.5 *New Monitoring Variables*

There has been a growing recognition that sampling the biota of a stream provides an effective, integrated indicator of changing water conditions (discussed in detail in Dissmeyer 1994). Also, stream bottom conditions such as embeddedness and the presence of pools can be meaningful measures of fish habitat potential for important species. Yet there has been little work in the Northeast on using these tools to monitor management impacts on stream conditions. With increased interest in cumulative effects (Sidle and Hornbeck 1991), these and other new monitoring tools need improved emphasis in the future.

### 7.1.6 *Streamside Management Zone Widths and Riparian Ecosystems*

The concept of "streamside management zones" (SMZs) seems to be replacing the concept of forested filter strips in the lexicon of forest management. There has been a much broader recognition of the landscape and habitat values of riparian areas (Wigley and Melchiors 1994; Peterson and Kimball 1995; Chase, Deming, and Latawiec 1997; Welsch 1991). This has led to significant increases in the recommended strip widths, based on assumed needs to protect wildlife movement and habitat and not just to shade the stream itself or filter sediment. For example, in a publication sponsored by several New Hampshire state agencies, a 100-foot "buffer" around streams and wetlands is recommended (Chase, Deming, and Latawiec 1997). This publication is of interest because of a detailed compilation of previous buffer width recommendations and studies (at pp. 24, 28, and 67). Evaluating these summaries is difficult because there is not enough local detail provided on each separate study. As its authors note, however, "there is no consensus on a single method for predicting appropriate buffer widths" (p. 23). The USDA Forest Service sponsored a major conference on riparian management in forests of the continental eastern United States in Columbus, Ohio, in March 1998.

In the well-watered East, even narrow SMZs will affect large amounts of land. In steeply sloping terrain, standard rules, which specify increasingly wide zones with increasing slope, will encompass larger and larger areas in the SMZs. Potential impacts on harvesting and on net returns can produce landowner resistance. Evaluating the actual economic costs of different SMZ widths and management restrictions becomes a very complicated task. This complexity is one reason why so little reliable cost analysis of the question is publicly available. Much of the cost of buffers is in the form of opportunity costs, not direct cash costs.

Discussion of buffer zones is often unclear and diffuse, and it is not made clear exactly what management actions, if any, would be permitted within them. Frequently, authors recommending wide buffer strips also concede that limited harvesting with no soil disturbance can be conducted in all or part of the buffer. On the other hand, traditional rules restricting cutting to a percent of basal area in each entry can result in the effective elimination of canopy cover in two to three entries. In such cases, the long-run results of compliance may not receive adequate consideration.

Clearly, however, the future will see an increased emphasis on multiple resource values of riparian zones and on BMPs designed to recognize such values. In many areas, poor windfirmness is a major constraint on prescriptions.

### 7.1.7 *Vernal Pools and Intermittent Streams*

In the 1990s, recognition of the importance of seasonally wet areas has increased (DeMaynardier and Hunter 1995). This has led to suggested BMPs or regulatory actions to protect vernal pools or intermittent streams. This in turn has led to increased discussion of methods for identifying these resources and for adopting workable regulatory definitions.

### 7.1.8 *Changing Climate or Other Changes*

Extensive research on climate change is being undertaken in order to attempt to understand climate patterns and how they may change in the future. While regional predictions are in their infancy at present, many climate experts assume that in the future there will be an increased incidence of extreme weather events compared to the past. If this conjecture is validated by more detailed analysis and forecasting, it could have implications for BMP design and implementation in the future. At present, it seems worthwhile to be alert to new developments in this field.

### 7.1.9 *Innovations in Techniques*

Improved education about BMPs, more effective enforcement, and improvements in a stewardship ethic among some landowners has led to a significant degree of innovation in techniques. These innovations are aimed at both increasing the effectiveness of water quality protection and reducing the cost. Examples include the use of new types for culverts for road surfaces and stream crossings (Kochenderfer 1995; Jamieson 1996; Blinn, Dahlmann, and Hilsop 1997), temporary bridges that avoid streambank disturbance, and the installation of abutments and fills that can constrict high flows and contribute sediment (Kittredge, Woodall, and Haver 1997; Legere 1998).

### 7.1.10 *Weakness of Existing Monitoring*

In its 1994 National Assessment (US EPA 1995a), EPA did not identify forest management as a significant source of water quality impacts on a national scale. There are difficulties in drawing strong conclusions from state assessments. First order and even second order drainages are often not evaluated. The assessments naturally focus on the larger waterways receiving diverse pollution loads and suffering noticeable loss of use values. Forest management is naturally a minor to unnoticeable contributor to pollution problems in such waterways. To the extent that sedimentation from logging roads and forest operations may occur, it is likely to be masked by agricultural or other sediment sources, or to be classified under “other” sources, and hence lost to view. Until baseline monitoring exists over wider forested areas, the benefits of protection programs will continue to be defined by anecdotes rather than by data. Also, state agencies should be capturing data in summary form on incidents and violations to build a cumulative record. At present, such information is lost in files.

### 7.1.11 *Debate Over Prescription vs. Design*

There is an ongoing debate over the issue that can be termed “prescription vs. design.” That is, between requiring strict compliance to rigid rules, or providing a process in which BMPs can be adapted to local conditions and requirements. In practice, a blend of approaches will probably be needed. Regulators may be reluctant to allow too much flexibility in implementation, seeing flexibility as a code word for lowering standards and making it more difficult to verify compliance. This problem is just one example of the extraordinary difficulty of designing regulations for private forest practices (Ellefson, Cheng, and Moulton 1995; Irland 1997).

The number of potential design variables is very large, and precise scientific guidance for design is often lacking. This is frequently cited as grounds for conservative (strict) rules. There would seem

to be very large potential gains for water quality, cost effectiveness, and effective administration if site condition based BMPs can be identified and validated. This is one reason that watershed analysis approaches have been adopted in some western states.

### 7.1.12 *Methods for Compliance Surveys*

Further attention should be paid to the methods used for assessing compliance, since implementing BMPs often requires some judgment. Further, omitting BMPs does not always result in sedimentation. The proper role of landowners and industry in implementation decisions needs some consideration as well. Generally, evaluations should be done in ways that maximize the independence of the investigators. Only in this way will results have maximum credibility to all parties.

Since existing surveys have used different approaches and personnel, it is difficult to compare results across states and over time. An effort is underway by the state foresters in the Northeast to develop a standard protocol for these surveys.

### 7.1.13 *Role for Auditing*

A number of trends are bringing the role of auditing to the fore. These include the growing interest in management systems such as ISO 9000. Additionally, large organizations such as the USDA Forest Service and paper companies have found that internal auditing of BMP compliance is a valuable management tool (Klocko 1998; DeGrace 1996). The SFI program has raised the visibility of the issue of auditing performance, though it has yet to accept a role for third-party audit. Individual members do employ third-party audits for some functions. Some corporations issue environmental performance reports, which depend in part on audit results. Finally, interest is increasing in environmental (green) certification of forestlands, which incorporates the independent auditing concept.

There is so much activity in this emerging area that an assessment of lessons learned to date would be of great value to land managers and regulators.

## 7.2 Long-term Monitored Watersheds

The region is fortunate in the concentration of intensive, long-term monitored watershed studies underway in and near it (Figure 7.1, Tables 7.1, 7.2, and 7.3). While these studies were installed for a variety of purposes, in nearly every case their results have assisted in understanding the effects of logging and road building on streams, as well as in designing more effective BMPs. Several short-term studies on impacts of cutting treatments are noted in state sections, but are not included here.

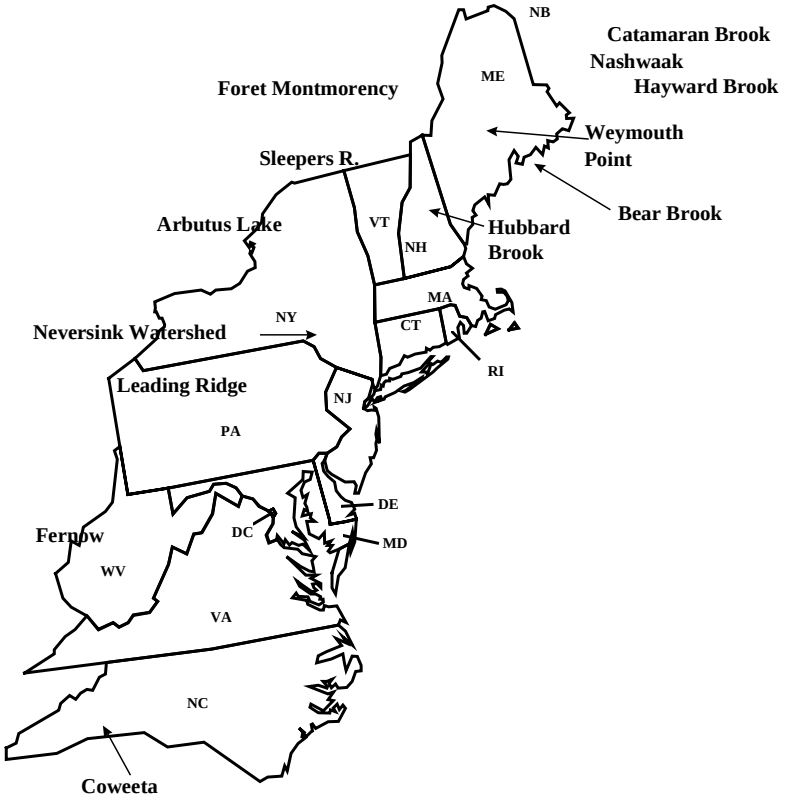


**Figure 7.1.** Long-term Monitored Watersheds and Major Impact Assessments (Note: Virginia and North Carolina are outside the region, but are included in this map to note the importance of the long-term work at Coweeta.)

**Table 7.1.** Contacts: Major Watershed Studies

**Fernow Experimental Forest**
James N. Kochenderfer
Pamela J. Edwards
Timber and Watershed Lab
Box 404
Parsons, West Virginia 26287
tel: 304-478-2000

**Leading Ridge Experimental Watershed Research Unit**
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Forest Resources Lab
University Park, Pennsylvania 16802
tel: 814-863-1933

**Hubbard Brook Experimental Forest**
C. Wayne Martin
Jim Hornbeck
Wyman Forestry Services Lab
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Durham, New Hampshire 03824
tel: 603-726-8902

**Sleepers River Research Watershed**
James B. Shanley
USGS
P.O. Box 628
Montpelier, Vermont 05601
tel: 802-828-4466

**Neversink Watershed Study**
Greg Lawrence
USGS
4250 Jordan Road
Troy, New York 12180
tel: 518-285-5664

**Hayward Brook Watershed Study**
Fundy Model Forest
Peter Etheridge, General Manager
RR #4, Acton Road
Sussex, New Brunswick E0E 1P0
CANADA
tel: 506-432-2806
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e-mail: fundyfor@nbnet.nb.ca

**Foret Montmorency**
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Faculty of Forestry and Geomatics
Local 3162 Pavillon Abitibi-Price
Universite Laval
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**Catamaran Brook Watershed Project**
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**Coweeta Hydrologic Lab**
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**Weymouth Point**
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College of Forest Resources
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University of Maine
Orono, Maine 04469
tel: 207-581-2854

**Huntington Forest, Arbutus Lake**
Myron J. Mitchell
College of Environmental Science and Forestry
State University of New York
Syracuse, New York 13210-2778
tel: 315-470-6765

**Nashwaak Experimental Forest**
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University of New Brunswick
Fredericton, New Brunswick
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tel: 506-453-4501

**Bear Brook Watershed in Maine**
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**Table 7.2.** Contacts: Forest Hydrologists

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Ray Newman, Dept. of Env. Mgt. & Eng.
Jack Clausen

**Massachusetts**
Paul Barten
tel: 413-545-4853

**West Virginia**
Anthony Tomkowski
tel: 304-293-2941, ext. 2422

**Pennsylvania**
James Lynch
tel: 814-865-8830
Rob Brooks
tel: 814-863-1596

**New York**
Peter Black
tel: 315-470-6571

**Vermont**
Tim Scherbatskoy
tel: 802-656-4057

**Vermont Monitoring Cooperative**
Sandy Wilmot
tel: 802-879-5687

**Quebec**
A. P. Plamondon
tel: 418-656-2620
Paul Beaulieu
tel: 418-656-5594

**Rhode Island**
None

**Maine**
Bob Shepard, teaches WS Mgt.
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Jim McLaughlin
tel: 207-581-2899

**New Jersey**
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**New Jersey, Rutgers**
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**New Hampshire**
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William Bowden
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**Maryland**
Dale Johnson
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**Maryland Appalachian Lab**
Keith Eshelman, Univ. of Maryland, Frostburg
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**Delaware**
Dr. Tom Sims
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**New Brunswick**
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tel: 506-851-6287
Peter Etheridge
tel: 506-432-2806

**Table 7.3.** Key Literature References: Major Watershed Projects

| Project | Citation |
|---|---|
| Fernow | Kochenderfer, Edwards, and Wood 1997 |
| Leading Ridge | Lynch and Corbett 1990 |
| Hubbard Brook | Hornbeck et al. 1993; Hornbeck et al. 1997 |
| Sleepers River | Shanley, Sundquist, and Kendal 1995 |
| Neversink | Lawence et al. 1994 |
| Hayward Brook (NB) | Pomeroy, Kerekes, and Pollock 1998 |
| Foret Montmorency (PQ) | Plamondon et al. 1998 |
| Nashwaak Experimental Forest (NB) | inactive |
| Weymouth Point | annual reports of Coop. For. Res. Unit, UMO |
| Coweeta | Stickney, Swift, and Swank 1994 |
| Huntington Forest, Arbutus Lake | Mitchell et al. 1996 |
| Bear Brook | Simmons 1996 |
| Catamaran Brook (NB) | Cunjak et al. 1993; Cunjak 1995 |

## 7.3 The State of Research: Some Impressions

In this region, there is an abundance of relevant experimental reports. Much of this work has been issued in formal Experiment Station reports or in refereed literature. It can be located through consulting directly with the leading research forests or the major bibliographies cited in the previous section.

Only a few recent field studies address BMP compliance and effectiveness in detail. In these studies, senior scientists are frequently not involved, sample sizes are small, rainfall intensities and relevant climatic influences are not measured, and results rarely appear in refereed literature. Further, it is not clear how representative the study sites may be of conditions in the entire northeastern region. While these field studies have produced valuable information, they were not intended to produce broad scientific generalizations. Therefore, it is useful to bear in mind their limitations when forming conclusions.

In many of the reports used for this study, the distinction between erosion and sedimentation is not always carefully observed in discussing results and implications. Also, assessments of erosion, soil disturbance, or sedimentation are usually based on ocular estimates that do not always use clear criteria. Frequently, sites are described as either having “a problem,” or not having one. This makes it impossible to assess the seriousness of the impact or the strength of the relationship to logging practices or other conditions. Further, the severity of particular rainfall events leading to erosion or sedimentation is never characterized. For these reasons, comparing different studies or using them to build an overall, quantitative picture is difficult. Because of these factors, there is no generally applicable statistical basis for relating soil conditions, rainfall intensity, degree of soil disturbance in

logging, use of BMPs, erosion, and resulting sedimentation in streams. Elsewhere, studies have used the Universal Soil Loss Equation, but we are not aware that its use has been validated in the Northeast.

A literature search and interviews suggest that the research community has largely turned its attention to topics other than sedimentation and BMPs. This results from two factors. The first is a sense that "the problem is solved" at the research level, and remaining impacts are of secondary importance. The second is that interest has increased in using the monitored watersheds for studying emerging issues such as acid deposition, forest health, and climate change. Thus, there is little new scientific literature emerging in this region that bears directly on the subject of this study.

This work did not attempt an authoritative or complete assembly of the relevant primary literature. Yet on the basis of what was examined, a few observations were made. First, there does not appear to be any interest by research funders in the problem of cumulative watershed effects (CWE). Second, there is little attention being paid to validating and refining relatively old recommendations concerning buffer widths, culvert design, and what passes for erosion hazard rating in these matters. Also, there is a dearth of current research on the relation between sediment discharged into streams and water quality, fish productivity, and aesthetics, and how these change over space and time. Finally, there is little current long-term research on the factors affecting restoration of soils and forest floor hydrologic integrity when BMPs are followed (however, see Reisinger, Pope, and Hammond 1992). If these impressions are correct, there are significant potential opportunities for focused field research to contribute to the development of more effective—and more cost-effective—BMPs.

The research available for this report provides no information enabling determination of the costs of implementing BMPs of varying levels of stringency (e.g., Irland 1986; Gregory, Niemi, and Mendelsohn 1989; and studies cited therein). Work on this problem is increasing in other regions (Alden et al. 1997; NCASI 1994; Ice and VanDuesen 1994; Stier and Martin 1997). Using BMPs can have offsetting benefits for landowners and loggers, but there is also no information on their size and occurrence. However, a USDA Forest Service (1987) publication provides a number of suggestive examples. Sound cost analysis studies would not be costly and would serve many useful purposes.

Differences in commitment to good management among landowners, foresters, and loggers accounts for much of the variability in compliance with and effectiveness of BMPs, but the social science aspects of the problem have been largely ignored. There is virtually no field research exploring how costs, timber returns, owner attitudes and needs, and other social and economic factors affect landowner and logger use of BMPs. This is in contrast to extensive literature that exists for agriculture (e.g., Lovejoy and Napier 1986; Halbach, Runge, and Larson 1987). There appear to be many lessons that can be learned from that body of research, but also many limitations (Lockeretz 1990, p. 523). As the Maine Department of Conservation (Maine DOC 1995) noted, "The question of why compliance with BMPs is low must be explored."

In agriculture, work has been increasing on these problems. Results have pointed to the difficulty of obtaining clear information with strictly voluntary programs, but the methods being employed in such studies should be reviewed for application in forestry (Wolf 1995; Patrick et al. 1992; Reice and Andrews 1998).

Finally, there is little or no comparative evaluation work assessing the effectiveness of current administrative programs, instruction and education efforts, and enforcement strategies. Policy makers seeking to improve the effectiveness of NPS programs in forestry have almost no methodologically solid and disinterested evaluation and public administration research to use in

designing improvements. A few useful general reviews exist (e.g., Bethea 1985). Work by Paul Ellefson and associates has made an excellent start in comparative analysis of state forestry practice regulatory programs nationwide (Ellefson, Cheng, and Moulton 1995).

## 8.0 GENERAL RECOMMENDATIONS

The analysis and interviews conducted for this project suggest a number of practical recommendations. To the extent that these ideas find support, it should be straightforward to identify logical groups and agencies for carrying them forward.

- Compliance Surveys

  States should conduct BMP compliance surveys every three to five years, using a large sample and a detailed assessment protocol. Such a protocol is now under development by the Northeastern Area State Foresters in cooperation with the USDA Forest Service. The surveys should be conducted in a manner to ensure an objective assessment, perhaps by an independent organization.

- Improved Equipment and Coverage: Water Monitoring

  A national effort needs to be conducted to mobilize engineering and technical capabilities to design and make available low-cost, durable equipment and support systems for monitoring of key water quality variables and recording the results in usable form. The high cost of monitoring is a barrier to obtaining stronger levels of confidence in knowing what does and doesn't work. For many field purposes, a continuous record of conditions may not be needed. Instead, a simple device that can be left in a stream and which can simply indicate whether, and when, some standard was exceeded could be very useful.

  A richer range of variables will need to be assessed in the future. Sediment content is obvious; but practical, low-cost methods of assessing streambed embeddedness or silt content and performing simple bioassays are needed. Long-term efforts will be needed to establish baseline natural variability in these characteristics. Low cost, long-lived, easily installed recording temperature probes are an example of the type of equipment needed for other parameters.

- Blue Ribbon Review of BMPs

  There is general agreement that BMPs effectively protect streams. Yet current BMP documents reflect the accumulation of past recommendations, assumptions, and compromises negotiated in committees. There has been little cross-fertilization between states and federal agencies to ensure wide use of the best ideas.

  A Blue Ribbon Review of current BMPs in the region needs to be conducted. A group of experts should be given suitable funding and assistance to formally review current silvicultural BMPs in several areas:

  …Is their scientific basis current and sound?

  …Are they clearly presented for users and enforcement agencies to interpret?

  …Are there weaknesses in their ability to protect waters?

  …Can a sound basis for rules regarding SMZs be found?

  …Are the current BMPs cost-effective in achieving their goals?

…Are definitions, especially for streams and wetlands, consistent with legal guidance, identifiable by land managers, and enforceable on the ground?

…Can immediate economic benefits from use of BMPs be shown?

…What are the tradeoffs between design approaches and rigid rules?

…Are modifications needed to address risks of infrequent but intense storms?

A valuable product of this review would be a guidance document providing a set of suggested elements for design of BMPs by the states.

- Public Administration Evaluation Agenda

  The implementation of programs for enforcing the water quality laws in forestry raises a large agenda of applied public administration research. Unfortunately, this agenda has been almost entirely overlooked. A major effort to fill this gap is needed. A regional group should be impaneled to plan a program of work in this area, seek sources of funding, and assess what can be learned today from low-cost research. This effort could be viewed as a way to search for the "best ideas" in administrative structures, interagency cooperation, procedures, and practices for administering, enforcing, and monitoring implementation and effectiveness of measures to protect water quality.

- Reviewing Training Efforts

  This group could look at the best methods for logger and landowner training, monitoring compliance, and enforcing BMPs. It is particularly important to improve the "technology transfer" of the most effective ideas from state to state within the region. Within the different states, industry, agency, and educational organizations are very active in this field. The American Pulpwood Association (1998) directory is a useful starting point. Continuing education approaches need to recognize the turnover within the occupation.

- Regional Research Priorities Review

  Research on BMP design and effectiveness is extremely costly. As a result, current BMP designs are often based on extrapolations from work done under different conditions, and on rules of thumb that are not well validated by experience. A regional effort should be made to identify:

  …current research activities and plans that are likely to yield new results within the region and in relevant nearby settings.

  …the priority near-term research needs on this subject.

- Improving Awareness

  States should consider measures to improve awareness of their current efforts and of the need to use BMPs. A number of possibilities include:

  …State Foresters should issue an annual or biennial report on the efforts being made to address water quality protection in their states. These reports could also be issued at regional levels by the NEFA and southern New England groups. At present, citizens or researchers seeking information on these programs must painstakingly gather it from a number of different individuals and agencies. A frequent report is a good means of opening up the process and also demonstrates agency commitment to the issue (Chesapeake Bay Program 1992).

…References to the state's BMP manual as required practice should be included in sample timber sale contracts that are distributed to landowners through educational and assistance programs (already done in some states).

…In the State Forests, managing agencies need to conduct periodic internal compliance monitoring and document the results in occasional reports.

…User-friendly BMP documents should be prepared, as Maine is attempting in 1998.

…The high turnover rate of landowners means that the education job is never finished. Program design needs to recognize this.

- Examine "Design" Approaches

  A serious research effort should be undertaken to supply guidance to regulators and practitioners on specific points in which "design" approaches to BMPs can be recommended.

- BMP Implementation Costs

  A series of case studies should be conducted using sound accounting and extended fieldwork to document costs of BMP compliance. With the large number of BMPs to address (Table 4.1) and the complexity of their effects, some setting of priorities will be needed.

**REFERENCES**

Adirondack Park Agency (APA). 1982. *APA rules and regulations*. October 15, 1982. Subtitle Q, Title 9. 126 pp. + app.

———. 1996. *APA 1995 annual report*. Ray Brook. 24 pp.

———. n.d. *Citizen's guide to Adirondack forestry*. 23 pp.

Alden, A.M., et al. 1997. *Timber harvester perceptions of benefits and costs of applying water quality BMPs in Minnesota*. University of Minnesota; College of Natural Resources; Department of Forest Resources Staff Paper Series No. 108. 61 pp.

Allegheny National Forest. FY 1995. *Monitoring and evaluation report*. 60 pp. + app.

American Forest and Paper Association (AF&PA). 1996a. *Sustainable forestry: BMPs to protect water quality*. Washington. 12 pp.

———. 1996b. *Sustainable forestry for tomorrow's world*. First annual report on the AF&PA; Sustainable Forestry Initiatives. Washington. 32pp.

American Pulpwood Association. 1998. *Fourth report on the status of statewide logger training and education programs in thirty forested states*. Rockville, MD: APA. Report 98-A-6. 65 pp.

AMP Technical Advisory Team. 1991. *Report of AMP Technical Advisory Team activities in Vermont*. Montpelier. 20 pp.

Anon. 1979. *Proceedings: Impact of intensive harvesting on forest nutrient cycling*. Syracuse: State University of New York; College of Environmental Science and Forestry; School of Forestry. 421 pp.

———. 1992b. *Timber harvesting ordinances in New York*. New York Society of American Foresters meeting (January 24, 1992).

———. 1996a. *BMPs for Pennsylvania forests*. University Park: Pennsylvania State University. 48 pp.

———. 1996b. Memorandum of Understanding (MOU) for high-elevation forest management, between Champion International Corporation, New Hampshire Fish and Game Department, and New Hampshire Division of Forests and Lands. Concord, NH. October 29, 1996. 12 pp.

———. 1996c. *Whole farm planning*. Walton: Watershed Agriculture Council. 12 pp.

———. 1997. *Monongahela NF trends report, FYs 1987-96*. Elkins, WV. July 25, 1997. 24 pp.

———. n.d. *VForEM forest ecosystem management demo project*. 4 pp. + app.

Baumgras, J.E. 1996. Environmental concerns affecting forest operations on public lands in the central Appalachians. In: C.R. Blinn and M.A. Thompson, (eds.). *Planning and implementing forest operations to achieve sustainable forests*. USDA Forest Service; Northeastern Forest Experiment Station. General Technical Report NC-186. pp. 40-46.

Belt, G.H., O'Laughlin, J., and Merrill, T. 1992. *Design of forest riparian buffer strips for the protection of water quality: analysis of scientific literature*. Moscow: University of Idaho; Forest, Wildlife, and Range Policy Analysis Group. Report No. 8. 35 pp.

Benoit, J., National Oceanic and Atmospheric Administration (NOAA), and Fox, J., United States Environmental Protection Agency (US EPA). 1997. Letter to R. Shinn, Commissioner, New Jersey Department of Environmental Protection, conditionally accepting Coastal Zone Act Reauthorization Amendments of 1990 program. November 18, 1997. 14 pp.

Bethea, J.M. 1985. Perspectives on NPS control: silviculture. In: *Perspectives on nonpoint source pollution*. Proceedings of a national conference at Kansas City, MO. USEPA 44015-85-001. 510 pp.

Birch, T.W. 1996. *Private forest-land owners of the United States, 1994*. USDA Forest Service, Northeastern Forest Experiment Station Resource Bulletin NE-134. 183 pp.

Birch, T.W., Gansner, D.A., Arner, S.L., and Widmann, R.H. 1992. Cutting activity on West Virginia timberlands. *Northern Journal of Applied Forestry*. 9(4):146-49.

Blinn, C.R., Dahlman, R., and Hilsop, L. 1997. Temporary stream and wetland crossing: many options, many choices. *Canadian Forest Industries*. Jan/Feb. pp. 44-48.

Briggs, R.D. 1997. *Assessing forest BMP compliance and effectiveness on harvested sites in New York, part II*. State University of New York; College of Environmental Science and Forestry. Syracuse, NY.

Briggs, R.D., Cormier, J., and Kimball, A.J. 1998. Compliance with forestry BMPs in Maine. *Northern Journal of Applied Forestry*. 15(2):57-68.

Briggs, R.D., Kimball, A.J., and Cormier, J. 1996. *Assessing compliance with BMPs on harvested sites in Maine, final report*. Maine Agricultural Experiment Station Miscellaneous Report 400. 35 pp.

Brown, D.B. 1993. BMPs for silvicultural activities in Pennsylvania's forest wetlands. Penn State University; School of Forest Resources. 53 pp.

Brown, T.C., and Binkley, D. 1994. *Effect of management on water quality in North American forests*. USDA Forest Service; Rocky Mountain Forest and Range Experiment Station; General Technical Report RM-248. 27 pp.

Brynn, D.J., and Clausen, J.C. 1991. Postharvest assessment of Vermont's acceptable silvicultural management practices and water quality impacts. *Northern Journal of Applied Forestry*. 8(1991):140-44.

Burns, R.G., and Hewlett, J.D. 1983. A decision model to predict sediment yield from forest practices. *Water Resources Bulletin*. 19(1). February 1993.

Cassidy, G.J., Aron, J.B., and Tremblay, M.J. n.d. (ca. 1996). *Best management practices for Rhode Island: water quality protection and forest management guidelines*. N. Scituate: Rhode Island Department of Environmental Management. 49 pp.

Catskill Center for Conservation and Development, Inc. 1997. *Summary guide to the terms of the watershed agreement*. Arkville, NY. 31 pp. + app.

Chase, V., Deming, L., and Latawiec, F. 1997. *Buffers for wetlands and surface waters: a guidebook for New Hampshire municipalities*. Concord: Audubon Society of New Hampshire. 80 pp.

Chesapeake Bay Program. 1992. *Progress report of the Baywide nutrient education re-evaluation*. Review draft. February 1992. 68 pp.

———. 1993. *Role and function of forest buffers in the Chesapeake Bay Basin for NPS management*. Nonpoint Source Committee, Forestry Work Group. Under contract to USEPA. 9 pp.

———. 1996a. *Forestry BMPs in the Chesapeake Bay Watershed: tracking accomplishments*. Nutrient Subcommittee, Forestry Work Group. 15 pp.

———. 1996b. *Final report*. Annapolis: Riparian Forest Buffer Panel. 8 pp.

*Connecticut Legal Journal* (CT LJ). 1995. DEP-certification of forest practitioners. Forest Practices Act, Title 23. Hartford: Department of Environmental Protection; Forestry Unit. February 21, 1995. 4 pp. + fact sheet.

Connecticut RC&D Forestry Committee. 1990. *A practical guide for protecting water quality while harvesting forest products*.

Connors, J., Murdoch, C., and Field, D. 1992. *Guide to forestry regulations in Maine*. Orono: University of Maine; Margaret Chase Smith Center. Technical Paper 07-01-92. 82 pp. + app.

Cooksey, R.A., and Todd, A.H. 1996. *Conserving the forests of the Chesapeake: the status, trends and importance of forests for the Bay's sustainable future*. USDA Forest Service, Northeastern Area-State and Private Forestry. NA-TP-03-96. 35 pp.

Cormier, J. 1996. *Review and discussion of forestry BMPs*. Augusta: Maine Department of Environmental Protection. 28 pp.

Cubbage, F. 1991. Public regulation of private forestry: proactive policy responses. *Journal of Forestry*. 89(12):31-35.

Cubbage, F.W., and Siegel, W.C. 1988. State and local regulation of private forestry in the east. *Northern Journal of Applied Forestry*. 5(1988):103-8.

Cullen, J.B. 1996. *BMPs for erosion control on timber harvesting operations in New Hampshire*. Concord: New Hampshire Division of Forests and Lands and Cooperative Extension Service; Forestry and Wildlife Resources Program. 65 pp.

Cunjak, R.A. 1995. Addressing forestry impacts in the Catamaran Brook Basin: an overview of the pre-logging phase. In: E.M.P. Chadwick, (ed.). *Water, Science, and the Public: The Miramichi Ecosystem*. Special Publication of the Canadian Journal of Fisheries and Aquatic Science. 123:191-210.

Cunjak, R.A. et al. 1993. *The Catamaran Brook (NB) habitat research project: biological, physical, and chemical conditions (1990-92)*. Technical Report of the Canadian Journal of Fisheries and Aquatic Science. 1914, 1993. Moncton, NB: Department of Fisheries and Oceans. 81 pp.

DeGrace, B. 1996. Environmental auditing of industrial forestlands: Fraser's experience. *Canadian Forest Industries*. Nov/Dec. pp. 40-43.

Delaware Department of Agriculture (DDA), Forest Service. 1995. *Delaware's forestry BMP manual*. Dover. 78 pp.

———. 1996 *Delaware's forestry BMP field manual*. Dover. 71 pp.

Delaware Department of Natural Resources and Environmental Control (DNREC). 1996. *State of Delaware, 1996 watershed assessment report 305(b)*. Dover. April 1996. var. pp.

DeMaynardier, P.G., and Hunter, M.L., Jr. 1995. The relationship between forest management and amphibian ecology: a review of the North American literature. *Environmental Review*. 3:230-61.

Dissmeyer, G.E. 1994. *Evaluating the effectiveness of forestry best management practices in meeting water quality goals or standards*. USDA Forest Service; Southern Region. Miscellaneous Publication 1520. 166 pp.

Dissmeyer, G.E., and Foster, G.R. 1980. *Guide to predicting street and rill erosion on forestland*. USDA Forest Service. Technical Publication SA-TP11. Atlanta, GA.

Egan, A., and Rowe, J.P. 1997. *Compliance with West Virginia's silvicultural BMPs, 1995-96*. Charleston. WVDOF-TR-97-1. 26 pp.

Ellefson, P.V., Cheng, R.S., and Moulton, R.J. 1995. *Regulation of private forestry practices by state governments*. Minnesota Agricultural Experiment Station Bulletin 605. 225 pp.

Empire State Forest Products Association (ESFPA). 1997. *Local regulation of timber harvesting in New York State*. Albany. 4 pp.

Eshelman, K.N. n.d. *Assessment of forest disturbance in the Mid-Atlantic region: a multi-scale linkage between terrestrial and aquatic ecosystems*. Project proposal 97-NCERQA-16. University of Maryland, Frostburg.

Essig. D.A. (comp.). 1991. *Report of survey results: implementation of silvicultural NPS programs in the U.S*. Washington: National Association of State Foresters. 17 pp.

Executive Office of Environmental Affairs. 1997. *Commonwealth of Massachusetts summary of water quality, 1996*. Worcester: Department of Environmental Management. 136 pp.

Forest Resources Advisory Council (FRAC), Assessment Working Group. 1996. *Report on field audit of AMPs for maintaining water quality on logging jobs in Vermont*. Montpelier. 16 pp. + app.

Gansner, D.A., Arner, S.L., Widmann, R.H., and Alerich, C.L. 1993. *Cutting disturbance in Pennsylvania: how much, where, and what*. Proceedings of Pennsylvania Forestry Issues Conference, forthcoming.

Gansner, D.A., Birch, T.W., Arner, S.L., and Zarnoch, S.J. 1990. Cutting disturbance on New England timberlands. *Northern Journal of Applied Forestry*. 7(1990). pp. 118-20.

Godwin, M.L., Wood, F., Adams, M.B., and Eye, M.C. 1993. Annotated bibliography of research related to the Fernow Experimental Forest. USDA Forest Service; Northeastern Forest Experiment Station; General Technical Report NE-174. 131 pp.

Gregory, R., Niemi, E., and Mendelsohn, R. 1989. A Model for Evaluating the Impacts of Forest Management Regulations. *Journal of Environmental Management*. 29:129-44.

Hagens, D.K., Weaver, W.E., and Madej, M.A. 1986. In: *Papers presented at the American Geophysical Union meeting on cumulative effects*. NCASI Technical Bulletin No. 490. New York, NY: National Council of the Paper Industry for Air and Stream Improvement, Inc. (NCASI). pp. 38-66.

Hagenstein, P.R. 1977. *Forest practices, water quality, and 208 plans in the Northeast*. USEPA, Region I. 28 pp.

Halbach, D.W., Runge, C.F., and Larson, W.E. 1987. *Making soil and water conservation work: scientific and policy perspectives*. Ankeny, IA: Soil Conservation Society of America. 174 pp.

Hawkes, L.J., et al. 1993. Forest water quality protection: a comparison of regulatory and voluntary programs. *Journal of Forestry*. May 1993. pp. 48-54.

Hickman, C.A., and Martus, C.E. 1991. Local regulation of private forestry in the eastern US. In: Chang, S.J. (comp.). *Environmental Concerns, Government Regulations, New Technology and Their Impact on Southern Forestry*. Proceedings of the Southern Forest Economic Workshop, February 20-22; Washington, DC. Louisiana Agricultural Experiment Station; Louisiana State University Agricultural Center. pp 73-87

Hornbeck, J.W., et al. 1986. *The northern hardwood forest ecosystem: ten year of recovery from clearcutting*. USDA Forest Service; Northeastern Forest Experiment Station; NE-RP-596. 30 pp.

———. 1993. Long-term impacts of forest treatments on water yield: a summary for northeastern USA. *Journal of Hydrology*. 150(1993):323-34.

———. 1997. Streamwater chemistry and nutrient budgets for forested watersheds in New England: variability and management implications. *Forest Ecology and Management*. 93(1997):73-89.

Hornbeck, J.W., and Leak, W.B. 1992. *Ecology and management of northern hardwood forests in New England*. USDA Forest Service; Northeastern Forest Experiment Station; General Technical Report NE-159. 44 pp.

Hornbeck, J.W., Martin, C.W., and Eagar, C. 1997. Summary of water yield experiments at Hubbard Brook Experimental Forest, NH. *Canadian Journal of Forest Research*. 27:2043-52.

Hornbeck, J.W., Martin, C.W., and Smith, C.T. 1986. Protecting streams during whole-tree harvesting. *Northern Journal of Applied Forestry*. 3(1986). pp. 87-100.

Horton, T., and Eichbaum, W.M. 1991. *Turning the tide: saving Chesapeake Bay*. Covelo, CA: Island Press.

Ice, G.G., Stuart, G.W., Waide, J.B., Irland, L.C., and Ellefson, P.V. 1997. 25 years of the Clean Water Act: how clean are forest practices? *Journal of Forestry*. 95(7):9-13.

Ice, G.G., and Van Deusen, P. 1994. An analysis of alternative riparian protection requirements on land available for management and the costs to landowners. In: *Abstracts of presentations: 1994 West Coast Regional Meeting*. Portland, OR: National Council of the Paper Industry for Air and Stream Improvement, Inc. pp. F4-F15.

Irland, L.C. 1985. Logging and water quality: state regulation in New England. *Journal of Soil and Water Conservation*. 40(1):98-101.

———. 1986. *Streamside protective corridors: techniques for weighing costs and benefits*. Unpublished paper presented to the International Union or Forest Research Organizations Congress, Ljublana, Yugoslavia. 43 pp.

———. 1995. *Land use and water quality in Maine: a historical perspective*. Unpublished overheads for Maine Water Quality Conference. 24 pp.

———. 1996. *Land, timber and recreation in Maine's Northwoods*. Orono: Maine Agricultural and Forest Experiment Station, Miscellaneous Publication 730. 81 pp.

———. 1997. Evaluating the impacts of forest practices acts: an initial research agenda for forest economists. In: MacFarlane, D., and Dennis, D. (comps.). *Proceedings of joint meeting of the Canadian and Northeastern forest economists, Fredericton, NB, 1996*. Fredericton: Canadian Forest Service; Atlantic Forestry Centre. pp. 103-26.

Irland, L.C., and Connors, J.F. 1994a. State nonpoint source programs affecting forestry: the 12 northeastern states. *Northern Journal of Applied Forestry*. 11(1):5-11.

———. 1994b. Controlling forest management impacts on water quality: the 12 northeastern states. *Land and Water*. Sept/Oct. pp. 42-45.

Jamieson, S. 1996. A little culvert, a lot of thinking. *Canadian Forest Industries*. Sept. pp. 8-14.

Kahl, S. 1996. *A review of the effects of forest practices on water quality in Maine*. University of Maine Water Research Institute. Report to Maine Department of Environmental Protection; Bureau of Water Quality Control. 52 pp., with cover letter dated October 16, 1996.

Karl, T.R., Knight, R.W., and Plummer, N. 1995. Trends in high-frequency climate variability in the twentieth century. *Nature*. 377:217-20.

Karl, T.R., and Knight, R.W. 1997. Secular trends of precipitation amount, frequency, and intensity in the USA. Submitted to *Bulletin of American Metropolitan Society*. 19 pp. + att.

King, K.S. 1989. *An analysis of New York State's timber harvesting guidelines*. New York Department of Environmental Conservation. 34 pp.

Kittredge, D.B., Woodall, C., and Haver, N. 1997. Massachusetts loggers rate portable skidder bridges. *Northern Logger and Timber Processor*. Oct. pp. 26-27, 36.

Kittredge, D.B, and Parker, M. 1995. *Massachusetts forestry BMP manual*. Massachusetts Department of Environmental Management, Office of Watershed Management; and USEPA, Region I.

Klocko, P. 1998. *Internal audits to improve harvesting excellence*. Rockville, MD: American Pulpwood Association Technical Release 98-R-3. 2 pp.

Kochenderfer, J.N. 1995. *Using open-top pipe culverts to control surface water on steep road grades*. USDA Forest Service; Northeastern Forest Experiment Station; General Technical Report NE-194. 7 pp.

Kochenderfer, J.N., et al. n.d. *Woodlot management; an introduction to water in the forest*. West Virginia University Extension and USDA Forest Service; Northeastern Forest Experiment Station. 28 pp.

Kochenderfer, J.N., Edwards, P.J., and Wood, F. 1997. Hydrologic impacts of logging on Appalachian watershed using West Virginia BMPs. *Northern Journal of Applied Forestry*. 14(4):207-18.

Kochenderfer, J.N., Helvey, J.D., and Wendel, G.W. 1987. Sediment yield as a function of land use in central Appalachian forests. In: *Proceedings of the Sixth Central Hardwood Forest Conference, Knoxville, TN, February 24-26*. pp. 497-502.

Koehn, S.W., and Grizzel, J.D. 1995. *Forestry best management practices: managing to save the Bay. Assessment and analysis report on forestry BMP implementation in Maryland*. Annapolis: Maryland Department of Natural Resources; Forest Service.

Land Use Regulation Commission (LURC). 1979. *A survey of erosion and sedimentation problems associated with logging in Maine*. Augusta: Land Use Regulation Commission; Maine Department of Conservation. 56 pp.

———. 1995. *Erosion control on logging jobs*. Augusta: Maine Department of Conservation. Preliminary review. March. 34 pp.

———. 1997. *Revised comprehensive land use plan*. March 27. 169 pp. + app.

Larson, W.E., Lindstrom, M.J., and Schumacher, T.E. 1997. The role of severe storms in soil erosion: a problem needing consideration. *Journal of Soil and Water Conservation*. 52(2):90-95.

Lawrence, G.B., et al. 1994. *Workplan of the Neversink Watershed Study in the Catskill Mountains of southeast New York*. Albany, NY: United States Geological Survey. Open file report 94-368. 42 pp.

Legere, G. 1998. Low-cost temporary stream crossings: why go around when you can go over? *Canadian Forest Industries*. April/May:55-58.

Lockeretz, W. 1990. What have we learned about who conserves soil? *Journal of Soil and Water Conservation*. 45(5):517-523.

Logger Licensing Technical Review Committee (LLTRC). 1998. *Making the current laws work: report of the LLTRC*. Augusta: Maine Forest Service; Department of Conservation. 30 pp. + app.

Lovejoy, S.B., and Napier, T.L. 1986. *Conserving soil: insights from socio-economic research*. Ankeny, IA: Soil Conservation Society of America. 155 pp.

Lynch, J.A., and Corbett, E.S. 1990. Evaluation of BMPs for controlling nonpoint pollution from silvicultural operations. *Water Resources Bulletin*. 26(1):41-52.

Maass, D. 1989. *Northern forest trends, 1985-88*. Augusta, ME: The Irland Group. 23 pp.

MacGregor, H.G. 1994. *R and D Report No. 10, Literature on the effects of environmental and forests on water quality and yield*. Fredericton, NB: Canadian Forestry Service; Maritime Region. 119 pp.

MacLean, C.A. 1994. *An analysis of inconsistencies in environmental protection standards pertaining to forest management activities in Maine*. Unpublished MS thesis. University of Maine, Orono. 150 pp.

Maine Atlantic Salmon Task Force. 1997. *Atlantic salmon conservation plan for seven Maine rivers*. Augusta. var pp. Web at http://www.state.me.us/governor/a-plus.htm.

Maine Council on Sustainable Forest Management (Maine CSFM). 1996. *Sustaining Maine's forests: criteria, goals, and benchmarks for sustainable forest management*. Augusta: Maine Department of Conservation. 54 pp.

Maine Department of Conservation (Maine DOC). 1995. *Background and mission statement: forestry advisory team (FORAT)*. Processed. 2 pp.

———. 1997. *FAQs about the logger licensing technical review committee*. Augusta. October 1997. 4 pp. processed.

Maine Department of Environmental Protection (Maine DEP). 1996. *1996 Maine water quality assessment*. Available on disk.

———. 1998. *NPS pollution: existing sources*. Report to the 118th Legislature, Joint Standing Committee on Natural Resources. Augusta. January 30. 31 pp.

Maine Forest Products Council. 1998. *Maine's sustainable forestry initiative*. Augusta. 11 pp.

Maine Forest Service (MFS). 1992. *BMP's, field handbook*. Augusta: Maine Forest Service. 36 pp.

———. 1994. Erosion and sediment control handbook for Maine timber harvesting operations best management practices. Augusta: Maine Forest Service.

Martin, C.W. 1988. Soil disturbance by logging in New England: Review and management recommendations. *Northern Journal of Applied Forestry*. 5(1):30-34.

Martin, C.W., and Hornbeck, J.W. 1994. Logging in New England need not cause sedimentation of streams. *Northern Journal of Applied Forestry*. 11(1):17-23.

Maryland Forest Service. 1993. *Soil erosion and sediment control guidelines for forest harvest operations in Maryland*. Annapolis. 120 pp.

Maryland Department of Natural Resources (MD DNR). 1996. *Maryland water quality inventory, 1993-1995*. Annapolis: Resource Assessment Service. 300 pp. + app.

Massachusetts Department of Environmental Management (MA DEM). n.d. *Wetlands Protection Act regulations (310 CMR 10.00) for administering MGL ch. 131, Sec. 40*. Bureau of Resource Protection, Division of Wetlands and Waterways. 154 pp.

———. n.d. *Ch. 132 guidance document, Massachusetts' Forest Cutting Practices Act (MGL ch. 132, s. 40-46)*. Division of Forests and Parks. 40 pp.

———. 1992. *Final (draft) general environmental impact report (GEIR) on forestland management practices*. Division of Forests and Parks. 373 pp. + app.

McComb, W.C., et al. 1991. Planning for basin-level cumulative effects in the Appalachian coal field. In: Rodiek, J.E., and Bolens, E.G. (eds.). *Wildlife and Habitats in Management Landscapes*. Washington: Island Press. pp. 137-52.

McCormack, M.L. Jr. 1984. *Interaction of harvesting and stand establishment in conifers in northeastern North America*. Proceedings of Conference Council on Forest Engineering, International Union of Forest Research Organizations. Fredericton, NB. August 17-18. pp. 233-39.

Miller, R.L. Jr., DeWalle, D.R., Brooks, R.P., and Finley, J.C. 1997. Long-term impacts of forest road crossing of wetlands in Pennsylvania. *Northern Journal of Applied Forestry*. 14(3):109-16.

Mitchell, M.J., et al. 1996. Climatic control of nitrate loss from forested watersheds in the northeastern United States. *Environmental Science and Technology*. 30(8):2609-12.

Moring, J.R., and Finlayson, K. 1996. *Relationships between land use activities and Atlantic salmon (Salmo solar) habitats: a literature review*. Maine Cooperative Fish & Wildlife Research Unit; University of Maine. Report to National Council of the Paper Industry for Air and Stream Improvement, Inc. (NCASI). 86 pp.

Myers, C.L. 1997. *Monongahela NF trends report for FYs 1987-96*. Elkins, WV. 24 pp. + att.

National Academy of Sciences. 1997. *Watershed research in the United States Geological Survey*. Washington: National Academy Press. 86 pp.

National Council for Air and Stream Improvement, Inc. (NCASI). 1979. *A survey of state assessment procedures for silvicultural nonpoint source control programs*. Special Report No. 79-02. New York, NY: National Council for Air and Stream Improvement, Inc.

———. 1992. *The effectiveness of buffer strips for ameliorating offsite transport of sediment, nutrients, and pesticides from silvicultural operations*. Technical Bulletin No. 631. New York, NY: National Council for Air and Stream Improvement, Inc. 48 pp.

———. 1994. *Benefits and costs of programs for forestry nonpoint pollution control in Washington and Virginia*. Technical Bulletin No. 660. New York, NY: National Council for Air and Stream Improvement, Inc. pp. 21-45.

New Hampshire Department of Environmental Services (NH DES). 1989. *New Hampshire NPS management plan*. Concord.

———. 1996. *State of New Hampshire 1996 Sec. 305(b) water quality report*. Concord. var. pp.

New Hampshire Forest Sustainability Standards Workteam. 1997. *Good forestry in the Granite State: recommended voluntary forest management practices for New Hampshire*. Concord: New Hampshire Division of Forests and Lands and Society for the Protection of New Hampshire Forests. var. pp.

New Jersey Bureau of Forest Management. 1995. *New Jersey forestry and wetlands BMP manual*. Trenton. 31 pp.

New Jersey Department of Environmental Protection (NJ DEP). 1995. New Jersey 1994 state water quality inventory report. Trenton. var. pp.

———. 1997. *Draft statewide watershed management framework document for the State of New Jersey*. January. 78 pp.

New Jersey Freshwater Wetlands Protection Act. NJSA 13:93-1, et seq.

New Jersey Freshwater Protection Act Rules. NJAC 7:7A.

New York State Department of Environmental Conservation (NYS DEC). 1997. *Draft nonpoint management program, 1997 update*. Albany. Division of Water. var. pp.

Nonpoint Source Task Force. 1985. *Final report on the federal/state/local NPS Task Force and recommended national NPS policy*. Washington: USEPA. 38 pp.

Northeast Forest Alliance (NFA). 1994. *Economic importance of Maine's forests*. Saranac Lake, NY. 12 pp.

O'Hayre, A.P. 1980. *Survey and analysis of silvicultural activities in relation to nonpoint source pollution in the State of Connecticut*. Connecticut Department of Environmental Protection; Forestry Unit.

Omernik, J.M., and Griffith, G.E. 1991. Ecological regions vs. hydrologic units; frameworks for managing water quality. *Journal of Soil and Water Conservation*. 46(5):334-40.

Parker, W.H., Jr. 1990. How Maryland's critical area protection program is affecting timber harvesting. *Proceedings of the 1990 Society of American Foresters National Convention*. Washington, DC. July 29-August 1.

Patric, J.H. 1980. Effects of wood products harvesting on forest soil and water relations. *Journal of Environmental Quality*. 9(1):73-80.

———. 1988. *A comparison of planned with established forest practices in Massachusetts*. Boston: Massachusetts Department of Environmental Management; Division of Forests and Parks. 48 pp.

Patric, J.H., and Helvey, J.D. 1986. *Some effects of grazing on soil and water in the eastern forest*. USDA Forest Service; Northeastern Forest Experiment Station: General Technical Report NE-GTR-115. 25 pp.

Patric, J.H., Evans, J.O., and Helvey, J.D. 1984. Summary of sediment yield data from forested land in the United States. *Journal of Forestry*. 82(2):101-4.

Patrick, R., et al. 1992. *Surface water quality: have the laws been successful?* Princeton: Princeton University Press. 192 pp.

Pennsylvania Department of Environmental Protection. 1998. *Pennsylvania stream releaf: A plan for restoring and conserving buffers along Pennsylvania streams*. Draft. Department of Environmental Protection Publication 3940-Bk-DEP2216. 23 pp. + app.

Pennsylvania Department of Environmental Regulation (PDER). n.d. *General permit, BDWM-GP-8. Temporary road crossings*. Harrisburg: Bureau of Dams and Waterway Management.

———. 1996. *Commonwealth of Pennsylvania 1996 water quality assessment*. Harrisburg. 94 pp.

Pennsylvania Department of Environmental Regulation (PDER), et al. 1992. *Controlling erosion and sedimentation from timber harvesting operations*. University Park: Pennsylvania State University. 26 pp.

Pennsylvania State University (PSU), and Pennsylvania Department of Environmental Regulation (PDER). n.d. *Controlling erosion and sediment pollution from timber operations "Prof. Timber harvesters action pocket."*

Perdue, J.L. 1990. Maryland's experience with logging plan permits. Are forests the answer? *Proceedings of the 1990 Society of American Foresters National Convention*. Washington, DC. July 29-August 1.

Peterson, S.C., and Kimball, K.D. 1995. *Citizen's guide to conserving riparian forests*. Gorham, NH: Appalachian Mountain Club. 82 pp.

Pierce. J.J. 1980. Strategies to control nonpoint source water pollution. *Water Resources Bulletin*. American Water Resource Association. 16(2):220-25.

Pierce, R.S., et al. 1993. *Whole-tree clearcutting in New England: manager's guide to imports on soils, streams, and regeneration*. USDA Forest Service; Northeastern Forest Experiment Station; General Technical Report NE-172. 23 pp.

Pinelands Commission. 1985. *The Pinelands of New Jersey*. Brochure.

Plamondon, A.P., Levesque, D., Ma, Y., and Prevost, M. 1998. Long-term effects of forest mosaic management on storm and snowmelt flow, Quebec. In: Wheater, H., and Kirby, C. (eds.). *Hydrology in a Changing Environment*. New York: John Wiley. vol. I, pp. 503-15.

Pomeroy, J., Kerekes, J., and Pollock, T. 1998. Pre-harvest characterizations of water chemistry and discharge for the Hayward-Holmes Watershed Study. Sussex, NB: *FMF Technical Notes*. 1(2):Winter 1998. 20 pp.

Powell, D.S., et al. 1993. *Forest resources of the US, 1992*. USDA Forest Service; Rocky Mountain Forest and Range Experimental Station; General Technical Report RM-234. 132 pp.

Putnam, W.C. n.d. *Implementation of best management practices in the northern region*. Range, Air, Watershed, and Ecology Group; Northern Region. pp. 92-97.

Quink, T.F. 1992. The Massachusetts Forest Cutting Act experience. In: *Proceedings of the Society of American Foresters 1992 Annual Convention*. pp. 468-71.

Reice, S.R., and Andrews, R.N. 1998. Effectiveness of regulatory incentives for sediment pollution prevention: evaluation through policy analysis and biomonitoring. In: USEPA/NFS. *1998*

*Water and Watershed Program Review*. Arlington: National Science Foundation. Abstract, p. 32.

Reisinger, T.W., Pope, P.E., and Hammond, S.C. 1992. Natural recovery of compacted soils in an upland hardwood forest in Indiana. *Northern Journal of Applied Forestry*. 9(4):138-41.

Rhode Island Coastal Nonpoint Source Control Program. 1995. Response to NOAA/EPA comments on Rhode Island's threshold review. Providence: Department of Environmental Management. Ch. 5, Forestry. 9 pp.

Rhode Island Department of Environmental Management (RI DEM). 1995. *Rhode Island NPS management plan*. NPS Program and Division of Planning. Report No. 87. var. pp.

Rubin, F., and Justice, D. 1995. *Final report: New Hampshire timber clear cut inventory*. Durham: University of New Hampshire; Complex Systems Research Center. 12 pp. + app.

Satterlund, D.R., and Adams, P.W. 1992. *Wildland Watershed Management*. Second Edition. New York: John Wiley. 436 pp.

Shanley, J.B., Sundquist, E.T., and Kendall, C. 1995. *Water, energy, and biogeochemical budget research at Sleepers River Research Watershed, Vermont*. USDA Forest Service. Open-file Report 94-475. 22 pp. Available from USGS Field Office, Montpelier.

Sidle, R.C., and Hornbeck, J.W. 1991. Cumulative effects: a broader approach to water quality research. *Journal of Soil and Water Conservation*. July-August:286-271.

Simmons, J.A., et al. 1996. Forest floor carbon pools and fluxes along a regional gradient in Maine, USA. *Forest Ecology and Management*. 84:81-95.

Society of American Foresters (SAF) Task Force on Reauthorization of the Clean Water Act. 1995. *Reauthorization of the Clean Water Act: forestry effects on water quality*. Report to the membership of the Society of American Foresters. 24 pp.

Spicer, D., and Mansius, D. 1997. *Maine Forest Service-Best Management Practices survey results*. Augusta: Department of Conservation. June. 4 pp.

Stafford, C., Leathers, M., and Briggs, R. 1996. *Forestry-related nonpoint source pollution in Maine: a literature review*. Maine Agricultural Experiment Station Miscellaneous Report 399. 18 pp.

Stickney, P.L., Swift, L.W., Jr., and Swank, W.T. 1994. *Annotated bibliography of publications on watershed management and ecological studies at Coweeta Hydrologic Laboratory, 1934-1994*. USDA Forest Service; Southeastern Forest Experimental Station; General Technical Report SE-86. 115 pp.

Stier, J.C., and Martin, A.J. 1997. Economic impacts of timber harvest regulations in the lower Wisconsin State Riverway. *Northern Journal of Applied Forestry*. 14(3)September:126-34.

Tetra Tech, Inc. 1993. *Summary of current state NPS control practices for forestry*. USEPA Office of Water. EPA-841/S-93-001. 2 vols.

Thompson, C.H., and Kyker-Snowman, T.D. 1989. *Evaluation of nonpoint source pollution problems from crossing streams with logging equipment and off-road vehicles in Massachusetts*. Massachusetts Department of Environmental Quality Engineering. Research and Demonstration Project 88-03. 78 pp.

Trieu, P.L., and Arnold, D.E. n.d. *Assessment of physiochemical and biological effects of two types of road surface on adjacent streams*. University Park: Pennsylvania Cooperative Fish & Wildlife Research Unit. 98 pp.

Turcotte, D.E., Smith C.T., and Federer, C.A. 1991. Soil disturbance following whole-tree harvesting in north-central Maine. *Northern Journal of Applied Forestry*. 8(2):68-72.

United States Comptroller General (US CG). 1990. *Water pollution: greater EPA leadership needed to reduce NPS pollution*. Washington. GAO/RCED-91-10. 56 pp.

———. 1992a. *Water pollution: EPA budget needs to place greater emphasis on controlling NPS pollution*. Washington. GAO/T-RCED-92-46. 9 pp.

———. 1992b. *Water quality: information on USDA's Water Quality Cost-share programs*. Washington. GAO/RCED-92-139 FS. 19 pp.

United States Department of Agriculture Forest Service (USDA FS). 1987. *Soil and water resource management: a cost or a benefit? Approaches to watershed economics through example*. Washington: Watershed and Air Management staff. 2 vols.

———. 1992. *FY '91 Monitoring and evaluation report*. Warren, PA: Allegheny National Forest. 60 pp. + app.

United States Department of Agriculture Soil Conservation Service (USDA SCS). 1987. *Second RCA appraisal*. Washington. 280 pp.

———. 1989. *Summary report: 1987 national resources inventory*. Iowa State University Statistical Lab, Statistical Bulletin No. 790. 37 pp.

United States Environmental Protection Agency (US EPA). 1985. *Chesapeake Bay Restoration and Protection Plan*. Washington: Chesapeake Executive Council. Government Printing Office. var. pp.

———. 1992. *Managing nonpoint source pollution. Final report to Congress, Sec. 319 Study*. Office of Water Programs. (WH-533) EPA-506/9-90. January. 2 vols.

———. 1993. *Guidance specifying management measures for sources of nonpoint pollution in coastal waters*. Office of Water. Washington, DC. 840-B-92-002. var. pp.

———. 1995a. *The quality of our nation's water: 1994*. Executive summary of the National Water Quality Inventory: 1994 Report to Congress. Washington. EPA 841-S-94-002. 209 pp.

———. 1995b. *The state of the Chesapeake Bay*. USEPA, Chesapeake Bay Program. Annapolis, MD. 45 pp.

———. 1998. *Clean water action plan: restoring and protecting America's waters*. Washington. 82 pp. Web: http://www.epa.gov/cleanwater.

United States Environmental Protection Agency (US EPA) and National Science Foundation (NSF). 1998. *1998 water and watersheds program review*. Arlington, VA: NSF. 92 pp.

United States Government Printing Office (US GPO). 1991. *Statistical abstract of the US, 1990*. 191 pp.

University of Vermont (UV) School of Natural Resources. 1990. *Impact assessment of timber harvesting activity in Vermont*. Final report. 108 pp.

Vermont Department of Forests, Parks, and Recreation (Dept. FP&R). 1997. *Intent to cut notification, emergency rules, standards, and procedures*. Waterbury. June 23.

Vigon, B.W. 1985. The status of nonpoint source pollution: its nature, extent and control. *Water Resource Bulletin*. 21(2):179-84. April.

Watson, B.C. 1997. *Comparative analysis of timber harvest BMPs*. Metropolitan District Commission-Quabbin, Providence Water, Hartford Metropolitan District Commission, and Pennsylvania Bureau of Forestry, Michaux State Forest. Prepared for the Northeast National Resource Center, National Wildlife Federation. 19 pp.

Welsch, D.J. 1991. *Riparian forest buffers, function and design for protection and enhancement of water resources*. Radnor, PA: USDA Forest Service; Northeast Area State and Private Forestry. NA-PR-07-91. 19 pp. + app.

West Virginia Department of Agriculture (WVDA). 1987. *1987 report on use of best management practices on logging operation in West Virginia*. 43 pp.

West Virginia Department of Natural Resources (WVDNR). 1989. *West Virginia nonpoint source assessment*. 90 pp.

West Virginia Forestry Division. 1989. *Soil erosion and water siltation*. 26 pp.

———. 1996. *BMP guidelines for controlling soil erosion and water siltation from logging operations in West Virginia*. Charleston. WVDOF-TR-96-3. 29 pp.

Whipkey, R.D. 1991. *An evaluation of the use and effectiveness of best management practices to control nonpoint sediment from logging operations in West Virginia*. West Virginia Division of Forestry Publication WVDOF 91-3. 45 pp.

Whipkey, R.D., and Bennett, L.B. (eds.). 1989. *West Virginia silvicultural water quality management plan*. West Virginia Division of Forestry Technical Report 89-6. 97 pp.

Whitman, R. 1989. Clean water or multiple use? BMP's for water quality control in the National Forests. *Ecological Law Quarterly*. 16:909-66.

Wigley, T.B., and Melchiors, M.A. 1994. Wildlife habitat and communities in streamside management zones: literature review for the eastern US. In: *Riparian ecosystems in the humid US: functions, values, and management*. Washington: National Association of Conservation Districts. pp. 100-38.

Wilmot, S., and Scherbatskoy, T. (eds.). 1997. *Vermont forest ecosystem monitoring. 1995 annual report*. Vermont Department of Forests, Parks, and Recreation. Waterbury. 302 pp.

Wolf, A.T. 1995. Rural nonpoint source pollution control in Wisconsin: The limits of a voluntary program? *Water Resource Bulletin*. 31(6):1009-22.