Trends for Forestry Best Management Practices Implementation

George G. Ice, Erik Schilling, and Jeff Vowell

ABSTRACT

The 1972 Clean Water Act initiated a national effort to address all sources of water pollution. One outcome was development of forestry nonpoint source control programs that use best management practices (BMP) and other tools to minimize water quality impacts. These programs can only be successful if BMPs are effective and if implementation rates are high. Many states have assessed rates of forestry BMP implementation with more than one survey and are beginning to develop histories that track trends. Trend data at the regional and national levels show generally high and increasing levels of implementation. Here, we use the volume of timber harvested in each state to adjust contributions to a national implementation average. The overall national forestry BMP implementation rate is estimated to be 89%. Factors contributing to increased implementation include federal and state legislation, regulation, and extension; certification programs; and public pressure.

Keywords: water quality, nonpoint source, best management practices

Since adoption of the 1972 Federal Water Pollution Control Act Amendments (a k a the Clean Water Act or CWA), control of nonpoint sources (NPS) of pollution has focused on implementation of best management practices (BMPs). BMPs are defined as "a practice or usually a combination of practices that are determined by a state or a designated planning agency to be the most effective and practicable means (including technological, economic, and institutional considerations) of controlling point and nonpoint source pollution at levels compatible with environmental quality goals" (Helms 1998, p. 15; Fig. 1). NPS contributions associated with forestry tend to be widespread and diffuse, and pollutants are often naturally occurring and difficult to distinguish from background. Significant NPS contributions are frequently a result of forcing climatic events such as intense or prolonged rainfall or rapid snowmelt. Forestry activities in particular are difficult to monitor because they move across the landscape, and management disturbances such as timber harvesting or site preparation at any one site can be separated by a prolonged period of forest growth. Because NPS impacts are difficult to measure and monitor, most NPS control programs track progress by monitoring BMP implementation and assessing the effectiveness of BMP for conditions common to the state. Development and adoption of BMPs for forestry is widespread (Archey 2004). Implementation of BMPs does not necessarily equal water quality protection because BMPs may or may not be effective, but when effective BMPs are implemented, water quality impacts are minimized (Sachet et al. 1980, Ice 2004, McBroom et al. 2008). This article assesses BMP implementation. Assessing national trends in implementation is complicated by different and evolving state BMPs and by different methods of measuring and reporting implementation. Here, we discuss evidence that BMP implementation for forestry has been increasing since the CWA was adopted. We also attempt to estimate the national average for BMP implementation based on volume of wood removed in each state.

Monitoring Implementation Rates

Since the beginning of NPS control programs there have been efforts to assess both implementation and effectiveness of BMPs (Ice et al. 1997). One of the earliest

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efforts was in the state of Washington (Sachet et al. 1980) and involved assessments in the field by an interdisciplinary team. The team concluded that "water quality was well protected when forest operations were conducted in compliance with the [forest practice] regulations" (state forest practice rules are considered BMPs; throughout this article we will use the term BMP). The team reported that compliance with BMPs was about 80%. Where BMPs were not implemented the team found that water quality impacts were common. Numerous states have attempted to assess rates of implementation of BMPs over the last 35 years. For example, forestry agencies in the 13 southern states have continued to develop BMP implementation monitoring methods to improve consistency within the region and to provide for statistically valid sampling (Southern Group of State Foresters [SGSF] 2008). Coordinated efforts among these states have produced a *Statistical Guidebook for BMP Implementation Monitoring* (Simpson et al. 2006), several BMP effectiveness projects (Vowell and Frydenborg 2004, Simpson et al. 2008b), and, most recently, a pollution load reduction model for BMP implementation (SGSF 2008). The most recent national summary of state water resource programs for silviculture by the National Association of State Foresters (NASF; Archey 2004) found that two-thirds of states monitor forestry sites for compliance with BMPs. These surveys have consistently shown high levels of BMP implementation.

Advancing Implementation

Many factors have contributed to increasing BMP implementation rates. The first state forest practices act specifically addressing water quality protection was adopted in Oregon in 1971, predating the CWA. Section 208 of the CWA focused attention on NPS pollution, including that from forestry activities. Later amendments provided funding and additional requirements for states to address and report on these NPSs. This legislation, along with implementing regulations, prompted states to develop NPS control programs and extension efforts to promote BMP implementation. State legislation and regulations have also shaped NPS control programs through forest practice acts, sediment control ordinances, streamside management zone (SMZ) laws, and other instruments.

Recently, forest certification programs requiring the use of state-recommended BMPs and protection of riparian areas have elevated implementation rates. Many wood products manufacturing facilities only accept timber from loggers with BMP training and many forest landowners allow only BMP trained loggers to operate on their properties. For example, a Weyerhaeuser Company (2009) website states that "All primary mills in the United States are independently certified as meeting the procurement provisions of the SFI [Sustainable Forestry Initiative] standard." "All of our primary mills in Canada are independently certified as meeting the chain-of-custody requirements of the CSA [Canadian Standards Association], PEFC [Programme for the Endorsement of Forest Certification schemes] or SFI standard." "All of our secondary wood products facilities are now certified to the SFI Fiber Sourcing standard." Similarly, a Louisiana-Pacific (LP) Corporation (2009) website states that "LP prefers to purchase timber from land certified by SFI, the American Tree Farm System, the Canadian Standards Association or the Forest Stewardship Council (FSC) when it is available. But when the source is not certified, as is often the case with small family-owned forests, LP's SFI-certified procurement process helps to ensure that timber comes from responsibly managed land." "SFI procurement requirements are clear. To be certified, you must develop a system that drives **best management practice** [emphasis added] from the forest to the mill." This has led to new opportunities for education and outreach for all levels of forest practitioners. The most recent BMP implementation survey in Texas found that timber harvest sites from which logs were delivered to SFI-certified mills showed higher levels of BMP implementation than those without known connections to certified mills (Simpson et al. 2008a). The widespread acceptance of certification programs indicates that many companies are committed to meeting public expectations for sustainable and environmentally sensitive forest management. Many other events have contributed to the continuing development of state forestry NPS control programs and implementation levels for forestry BMPs (Table 1, although the table is not comprehensive).

Figure 1. BMPs can dramatically reduce impacts from management activities. Here, similar forest road cuts without and with mulch and grass show the potential effectiveness of BMPs in providing cover and erosion resistance. BMPs are designed to reduce both generation and delivery of pollutants to streams and other waterbodies.

The ongoing evolution of BMPs, especially at the state level, is hidden in Table 1. A dynamic tension continues between what forest practices and restrictions (e.g., riparian management areas) are needed to protect water quality and what limitations create unacceptable hardships and disincentives to forest landowners. This evolution is represented by changes in the BMPs addressing streamside management areas in Oregon. The first rules adopted in 1972 were general and provided guidance but allowed great discretion to the operator. For example, one option was "where it is difficult to leave buffer strips of timber to shade a stream, plan to reestablish cover without delay, along the stream, after cutting is completed." This contrasts with current rules that have strict requirements for minimum numbers, sizes, and types of trees (conifer or hardwood) to be left in streamside management areas, along with minimum cumulative basal areas for the residual stands. The current riparian rules in Oregon are also adjusted for different regions, beneficial uses, stream sizes, and harvest activities. Over more than 35 years of implementation, the rules have become more detailed and prescriptive. This evolution is repeated in most states that experience periodic reviews of state BMP. New BMPs are considered as

Table 1. Timeline of best management practices implementation.

Year	Event
1971	Oregon Forest Practices Act passed
1972	Federal Water Pollution Control Act Amendments passed
1977	Environmental Protection Agency guidelines for state NPS control programs allow flexible approaches
1987	CWA amendments adopt Section 319 to strengthen NPS programs
1993	FEMAT report published
1994	SFI certification program established; will ultimately require participants to use state BMPs
1997	Lawsuits under Section 303(d) of the CWA addressing "impaired" waters force EPA to issue new guidance requiring timelines for completion of Total Maximum Daily Load assessment
1999	PEFC formed
1999	EPA proposes to reclassify forestry as a point source of pollution
2000	EPA withdraws proposal to classify forestry as a point source of pollution
2002	SGSF silvicultural BMP implementation monitoring—a framework for state forestry agencies released
2005	EPA's latest version of National Management Measures under 1972 Coastal Zone Management Act released
2007	EPA begins review of forest roads for possible reclassification under the CWA
2008	SGSF's implementation of forestry BMPs—a southern region report released
2009	States continue to monitor and assess both implementation and effectiveness of forestry BMPs and NPS control programs

EPA, Environmental Protection Agency; FEMAT, Forest Ecosystem Management Assessment Team

new issues arise. For example, there is ongoing consideration of new BMPs for some states in the South that have karst topography.

Southern Foresters' Report

One of the challenges to estimating a national average for BMP implementation is the inconsistency in how BMP implementation rates are monitored and reported. To address the issue of monitoring inconsistencies, states in the southern and northern United States in particular have attempted to develop uniform methods for measuring BMP implementation rates. The SGSF, representing 13 southern states, developed an approach that provides an implementation monitoring framework for state forestry agencies in that region (BMP Monitoring Task Force 2002). The framework addresses monitoring frequency, site selection criteria, specific BMPs to be evaluated, evaluation and scoring methodology, risk assessment, and follow-up actions. It also includes a *Statistical Guidebook for BMP Implementation Monitoring* (Simpson et al. 2006) to assist state forestry agencies in developing a statistically sound monitoring process. The principal objective of the framework was to establish consistency among the southern states regarding BMP implementation monitoring so that regionwide data could be collected, analyzed, and reported. A report titled *Implementation of Forestry Best Management Practices: A Southern Regional Report* was published in 2008 (SGSF 2008). It compiled regional implementation data for seven BMP categories: timber harvesting, site preparation, forest roads, stream crossings, SMZs, chemical application, and firebreaks. Based on regional averages, the individual categories scored at least 85% implementation, except the firebreaks category at 73%. Combining all practices in all categories showed the overall regional BMP implementation rate to be 87%, and "in states where multiple surveys were reported, overall implementation showed a generally positive trend" (SGSF 2008). The most frequent and consistent of these surveys came from Florida (Fig. 2) (Vowell et al. 2008). It showed that implementation went from a low of 84% in 1985 to 99% in 2007.

Northern Region BMP Implementation Monitoring Guidelines

States in the Northeast have developed strong regulatory approaches for oversight of forest management but have traditionally dedicated little attention to evaluating BMP performance. In response, the US Forest Service Northeastern Area State and Private Forestry, in conjunction with the Northeastern Area Association of State Foresters (NAASF) Water Resources Committee, developed a protocol for assessing the implementation and effectiveness of forestry BMPs (Welsch et al. 2007). Presence or absence of a particular BMP prescription is generally what is evaluated by most states when assessing BMP implementation and effectiveness. However, the Northeast BMP Monitoring Protocol was developed to provide an economical, standardized, and repeatable methodology that assesses the underlying principles of water pollution prevention (controlling water flow, stabilizing disturbed soil, managing chemical pollutants, minimizing biological impacts, and preharvest planning) rather than tallying individual BMP prescriptions' use or absence.

The monitoring protocol evaluates BMP performance for sample units (i.e., stream crossings, haul roads, log landings, rutting, SMZs, forest chemicals, mineral soil skid trail inside SMZs, and wetland crossings) within a harvest tract. Individual tracts, therefore, may have multiple sample units or none at all, depending on the sampling design used by a state. Sampling based on evaluation of individual sample units is used to avoid the problems associated with averaging BMP implementation and effectiveness across an entire timber sale. To assess the effectiveness of BMPs for controlling the flow of water off a forest haul road, e.g., auditors evaluate whether or not eroded soil from the road surface reaches a stream and measure the distance the soil moved from the road and toward the stream. In effect, auditors assess the overall effectiveness of a suite of forest road BMPs to control erosion as opposed to evaluating individual BMPs (e.g., correct water diversion structure spacing and correct road grading). This approach, therefore, facilitates consistent data collection across a wide array of state BMPs within the region (Welsch et al. 2007).

In 2006, Maine and Wisconsin published results from initial surveys evaluating the feasibility of the US Forest Service/NAASF BMP monitoring protocol (Maine Department of Conservation [ME DOC] 2006; Shy and Wagner 2007). Overall, the states were encouraged by the results, and Wisconsin is developing a hybrid sampling protocol that integrates US Forest Service/NAASF BMP monitoring procedures with the state's traditional monitoring metrics (Shy and Wagner 2007). Furthermore, both states noted continued improvement in BMP compliance rates. When properly applied, Maine's BMPs for stream crossing approaches avoided soil transport to waterbodies 92% of the time (ME DOC 2006). In Wisconsin only 1% of approaches monitored showed trace amounts of sediment reaching waterbodies (Shy and Wagner 2007). Traditionally a problem area within all states, compliance with stream crossing BMPs continues to show improvement as a

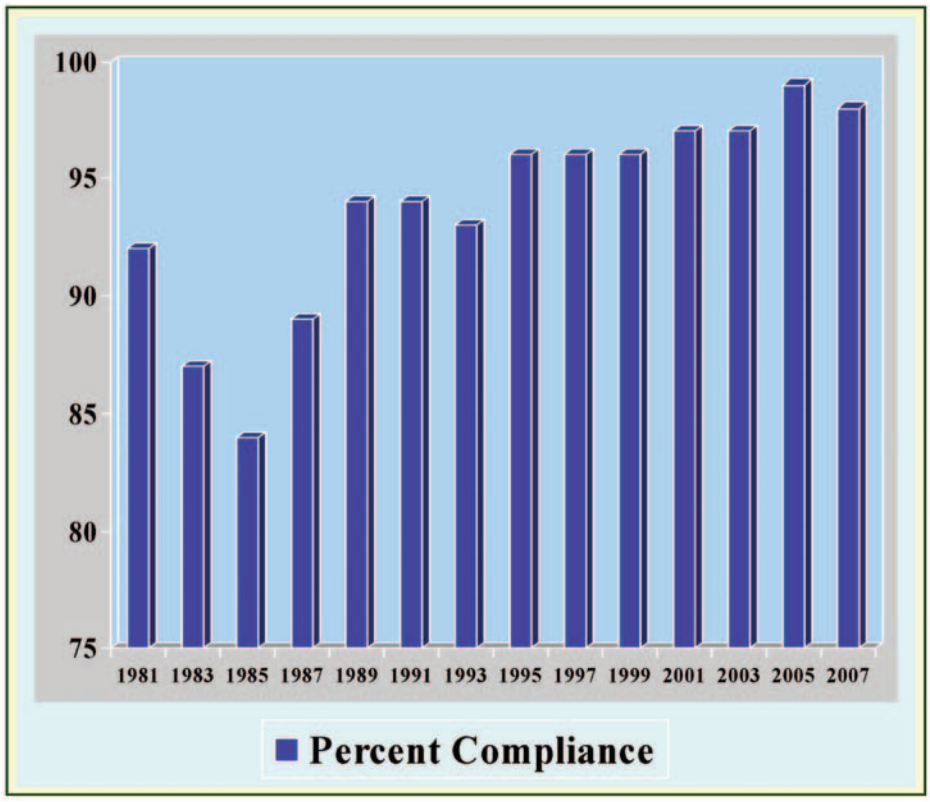

Figure 2. BMP implementation for Florida. (Source: Vowell et al. 2008.)

result of increased education of landowners and managers as well as increased acreage of certified forestland in the region (Schilling et al. 2009).

Montana Trends

Another mature set of BMP implementation data comes from Montana (Ziesak 2008). Montana conducts BMP audits every 2 years using trained assessment teams. These audits show a change from less than 80% implementation in the early audit years to 97% in the most recent surveys. As with other state assessments, the Montana audits identify problem practices and allow the state to develop education and other approaches to increase BMP implementation (Fig. 3).

Developing a Nationwide Estimate

Past efforts to estimate the nationwide rate of BMP implementation have used a simple average of states that reported rates. The NASF has periodically surveyed its members to summarize state programs addressing NPS pollution control for forestry activities (see Archey 2004 for the most recent report). In the previous NASF report, Ice and Stuart (2001) estimated that the national average BMP implementation rate was 86% and noted that one-half of the states reported BMP implementation rates greater than 94%. However, this approach to establishing a national average for BMP implementation has some significant flaws.

First, the national average is based only on data from states that monitor for BMP implementation and report the results. States where BMP programs are not comprehensive may not conduct BMP implementation surveys or may do so on a limited basis. This is a particular problem for estimating trends, because states with less mature BMP programs may report in later surveys. This could cause the national average to drop and give a false impression that nationwide implementation has declined (because implementation was previously overestimated). Conversely, a national average based on a relative few mature programs may overestimate implementation because less active BMP programs (presumably with lower implementation rates) are not included.

Another significant problem is that a simple average of states does not reflect levels of forestry activities. Data on BMP implementation from New Mexico and Oregon count equally for this type of calculation, even though harvest levels are different. If simple rates of implementation reported for these two states (Ice and Stuart 2001: New Mexico, 75%; Oregon, 98%) are averaged, the overall rate is 86.5%. If the level of forestry activity is scaled based on harvest levels, the overall BMP implementation average is 97.7% ([75 × 13,623 ft^3/1,053,473 ft^3] + [98 × 1,039,850 ft^3/1,053,473 ft^3]).

Data about BMP implementation are also missing for some states. Fortunately, the top 16 states for volume of removal, representing more than 81% of the cumulative volume of harvest in the United States, do have recent BMP implementation data. There are more data gaps for the next 18 states in removal rank. Some data are more than 10 years old and others are missing. For this national estimate we have filled in gaps by using data from adjacent states. Where data are old we have noted it in the table but still used it. This undoubtedly results in a conservative (lower) estimate of BMP implementation. Data on implementation from the 16 lowest removal volume states are scant, with only 3 of them reporting. Cumulatively, these states total less than 1% of the national removal volume so their effect on the national BMP implementation rate is small. Where BMP implementation data are missing for these lowest 16 states we have substituted an estimate of 50% implementation to be conservative. Whether we assume 50% or 90% implementation for these states has little affect on the overall national average but is certainly an important issue at the individual state level.

Finally, there can be differences among states in the way implementation is assessed and reported. In some cases states may report compliance levels based on the spirit (overall meeting resource protection goals) or the letter (meets or exceeds specific prescriptions) of the BMP. A recent audit from Washington (Lingley et al. 2009) provided a demonstration. Compliance with BMPs is reported to be 80%. This represents the compliance level for each individual rule for SMZs and roads. However, the BMPs for Washington are extremely complex and can be confusing to apply. If trivial departures from the BMPs unlikely to cause resource damage (e.g., cutting one tree too many at the outer edge of the riparian protection area) are included, the compliance rate rises to 89%. Compliance could also be reported as the number of operations or sites where all BMPs were applied correctly or where major water quality impacts were avoided. This

speaks to the value of having more consistency, at least at regional levels, for implementation monitoring. Table 2, based on a review of forestry NPS programs (Schilling et al. 2009), shows estimated BMP implementation rates for all 50 states in the United States. These rates are for individual BMPs. New information was used where possible (Andrea 2008, Ziesak 2008).

Based on these data and removal values from Smith et al. 2009 (2006 values, Table 2), we estimate the adjusted national average BMP implementation rate to be 89%. For the many reasons discussed previously, this should be considered an approximation. However, we can more confidently state that for the top 16 wood volume removal states, representing 81% of the cumulative volume of timber removal in the United States, BMP compliance is greater than 90%.

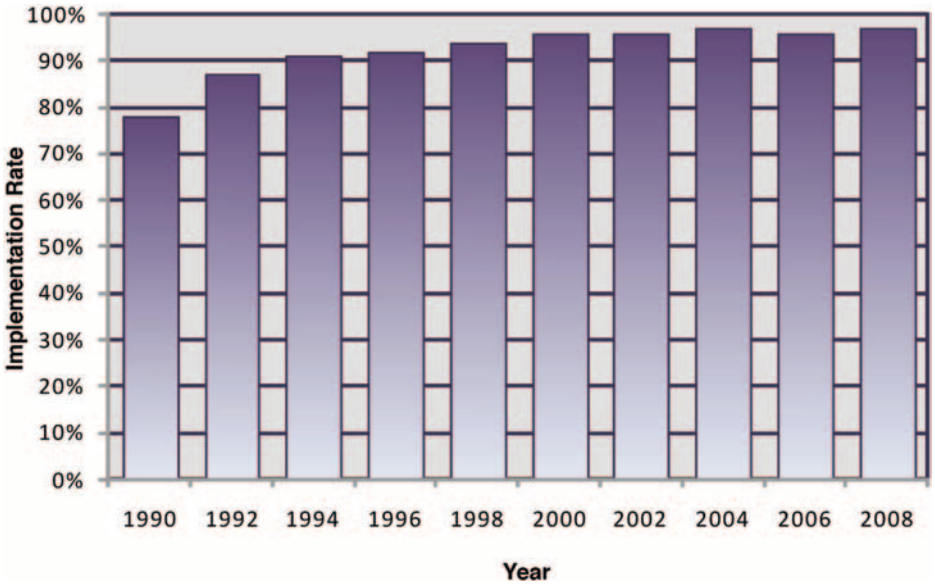

Figure 3. Audit results from Montana for BMP implementation from 1990–2008. (Source: Ziesak 2008.)

Improving Implementation Rates

In addition to determining rates of implementation, another objective of BMP monitoring is to identify practices, categories of practices, or geographic areas with less than satisfactory implementation rates. Once problems are identified, specialized training that focuses on specific practices or categories of practices can be conducted and can involve foresters, forest landowners, loggers, or other practitioners as appropriate. Likewise, monitoring can identify geographic areas within states where BMP implementation rates are relatively low. This may be caused by changing ownership patterns, unique physiographic conditions, or other factors. In the Southeast, the SGSF Water Resource Committee meets regularly to discuss BMP programs and, specifically, to review implementation issues. The committee, which is made up of state BMP program managers, has frequently used such meetings to identify common implementation problems and develop training materials and methods to be shared among the states. For example, Florida developed a logger "tailgate" training program whereby audiovisual educational material was delivered directly to logging sites instead of requiring loggers to shut down operations and attend conventional classroom sessions. Likewise, North Carolina developed a "bridge-mat" program, in which the state purchased portable stream crossing structures and made them available to loggers or landowners at no cost. These and other successful training programs have been shared with and duplicated by other states in the region to help improve implementation rates and better protect water quality. Consequently, the generally high and continually improving rates of BMP implementation in this region are largely attributed to investments in training programs at both the state and the regional levels.

Summary and Conclusions

BMP implementation is a key factor in judging the effectiveness of forestry NPS control programs. As a result, many states have conducted implementation assessments and some states have made multiple assessments over time. Implementation shows a clear trend upward in most states. Developing a realistic estimate of nationwide BMP implementation is confounded by many factors, including different and evolving state BMPs, different methods of monitoring and reporting, an absence of data from some states, and changing levels of timber management. However, an adjusted national average of 89% (weighted for annual removal volumes) was based on the most recent BMP implementation results reported by states. In the future, these results can be refined with development of more uniform monitoring and reporting methods, such as those being developed in the South and the Northeast.

Although we report here on implementation rates, the other half of the water quality and beneficial use equation is BMP effectiveness. State BMPs have become increasingly sophisticated and detailed, resulting in increased protection to forest streams, lakes, and wetlands. For example, a recent paired watershed study in Texas found that contemporary practices with BMPs reduced sediment losses by 80% compared with an earlier harvest followed by shearing and windrowing without BMPs (McBroom et al. 2008). Ice (2004) found that BMPs often reduced undesired water quality impacts by 90% or more. Many states have conducted effectiveness monitoring and research to ensure that their BMPs are achieving their water quality goals. This monitoring and research can range from field audits by professional teams looking for signs of water quality impacts (e.g., Sachet et al. 1980, Ziesak 2008) to biological assessments (Vowell and Frydenborg 2004, Simpson et al. 2008b), paired watershed studies (e.g., Miwa et al. 2006), process-based research (Oregon Department of Forestry [ODF] 2003), and modeling (Elliot 2004, SGSF 2008).

Of the top 10 states for volume of timber removed, all but 3 report implementation rates of 92% or greater. Perhaps the most curious of these results is from Washington, with a strict regulatory program and detailed BMPs yet only 80% implementation. As noted, however, if trivial departures from the rules were included, the rate would be 89%, and some of the reduction in implementation is a result of new, more detailed and complicated rules. Thus, even though overall BMP compliance with indi-

Table 2. Annual removals (2006 values, Smith et al. 2009) and reported best management practices implementation rates by state (Schilling et al. 2009).

State	Removals (1,000 ft^3)	Implementation rate (%)	State	Removals (1,000 ft^3)	Implementation rate (%)
Georgia	1,340,534	92	Alabama	1,157,330	96
Mississippi	1,093,943	93	North Carolina	1,074,973	82
Oregon	1,039,850	96	Washington	899,047	80
Louisiana	857,907	96	Arkansas	810,279	86
South Carolina	671,532	95	Texas	658,718	92
Virginia	644,260	82	Florida	574,525	99
Maine	490,003	75	California	469,231	94
Wisconsin	453,883	96	Tennessee	377,516	82
Minnesota	372,294	71	Michigan	364,343	84 (est)
Kentucky	296,298	68	Idaho	245,740	96
Pennsylvania	211,921	85 (est)	Montana	197,903	97
Missouri	187,226	82 (est)	New York	158,454	77 (1998)
West Virginia	158,373	85	Oklahoma	138,533	92
Indiana	101,337	88	Illinois	77,655	84 (est)
Ohio	72,430	84 (est)	Alaska	66,144	89
Vermont	43,942	61 (1988)	New Hampshire	39,591	61
Maryland	38,091	81	South Dakota	23,245	92
Iowa	22,285	50 (est)	Wyoming	15,072	97
New Mexico	13,623	75	Colorado	12,505	50 (est)
Arizona	10,369	50 (est)	Massachusetts	9,524	50 (est)
Kansas	7,599	50 (est)	Delaware	7,560	50 (est)
Nebraska	7,391	50 (est)	Connecticut	6,000	50 (est)
Utah	5,418	85	New Jersey	3,730	50 (est)
North Dakota	2,929	50 (est)	Rhode Island	1,465	50 (est)
Nevada	964	50 (est)	Hawaii	0	50 (est)
National Total	15,533,482	89			

est, estimate.

vidual rules has remained about the same between the earliest and latest surveys, the level of protection has increased. Together, effective BMPs and a high rate of BMP implementation result in low NPS impacts and help protect the water quality and beneficial uses of streams, lakes, and wetlands in forested environments.

Literature Cited

ANDREA, A. 2008. *Idaho forest practices year-end report.* Idaho Department of Lands.

ARCHEY, W. 2004. *The National Association of State Foresters: 2004 progress report—State water resources programs for silviculture.* The National Association of State Foresters, Washington, DC. Available online at www.stateforesters.org/node/811; last accessed Dec. 9, 2009.

BEST MANAGEMENT PRACTICES (BMP) MONITORING TASK FORCE. 2002. *Silviculture best management practices implementation monitoring.* Southern Group of State Foresters, Water Resources Committee. Available online at www.southernforests.org/documents/BMP%20Framework%20Protocol.pdf; last accessed Dec. 9, 2009.

ELLIOT, W.J. 2004. WEPP Internet interfaces for forest erosion prediction. *J. Am. Water Resour. Assoc.* 40:299–309.

HELMS, J.A. (ED.). 1998. *Dictionary of forestry.* Society of American Foresters, Bethesda, MD. 210 p.

ICE, G.G. 2004. History of innovative best management practice development and its role in addressing water quality limited waterbodies. *J. Environ. Eng.* 130(6):684–689.

ICE, G.G., G.W. STUART., J.B. WAIDE, L.C. IRLAND, AND P.V. ELLEFSON. 1997. 25-years of the Clean Water Act: How clean are forest practices? *J. For.* 95(7):9–13.

ICE, G.G., AND G. W. STUART. 2001. *National Association of State Foresters 2000 progress report: State nonpoint source pollution control programs for silviculture.* National Association of State Foresters, Washington, DC. 26 p.

LINGLEY, L., D. GREGORY, AND A. SHELLY. 2009. *Compliance monitoring summary report: Biennium 2006–2007.* Washington State Department of Natural Resource, Olympia, WA. 71 p.

LOUISIANA-PACIFIC CORPORATION. 2009. *Forest certification.* Available at www.lpsustainability.com/environmental_responsibility/sustainable_forestry/forestry_certification.html; last accessed Dec. 9, 2009.

MAINE DEPARTMENT OF CONSERVATION (ME DOC). 2006. *Maine forestry best management practices use and effectiveness 2005.* Maine Department of Conservation, Forest Service, Augusta, ME. 63 p.

MCBROOM, M.W., R.S. BEASLEY, M. CHANG, AND G.G. ICE. 2008. Storm runoff and sediment losses from forest clearcutting and stand re-establishment with best management practices in East Texas, USA. *Hydrol. Proc.* 22:1509–1522.

MIWA, M., W.B. SUMMER, S. TERRELL, M.W. GRISWOLD, D.G. JONES, R.T. WINN, AND M. BELL. 2006. Timber harvesting effects on small headwater riparian wetlands in southwestern Georgia. P. 99–106 in *Proc. of the int. conf. on Hydrology and management of forested wetlands.* American Society of Agricultural and Biological Engineers, St. Joseph, MI.

OREGON DEPARTMENT OF FORESTRY (ODF). 2003. *Riparian function and stream temperature: Effectiveness of Oregon Department of Forestry's protection rules and strategies*, Ver. 2.2. Available online at www.egov.oregon.gov/ODF/privateforests/MonitoringRipStream.shtml; last accessed Dec. 9, 2009.

SACHET, J., S. KELLER, A. MCCOY, T. ORR, AND N. WOLFF. 1980. *An assessment of the adequacy of Washington's forest practice regulations in protecting water quality.* DOE 80-7, Washington Department of Ecology, Office of Water Programs, Olympia, WA. 76 p.

SCHILLING, E.B., G.G. ICE, T.B. WIGLEY, AND A.A. LUCIER. 2009. *Compendium of forestry best management practices for controlling nonpoint source pollution in North America.* Tech. Bull. 966, National Council for Air and Stream Improvement, Inc., Research Triangle Park, NC. 208 p.

SHY, K., AND C. WAGNER. 2007. *Wisconsin's forestry best management practices for water quality 2006 BMP monitoring report.* PUB-FR-391-2007, Wisconsin Department of Natural Resources, Division of Forestry, Madison, WI. 35 p.

SIMPSON, H., J. GREIS, AND R. MCNEW. 2006. *Statistical guidebook for BMP implementation monitoring.* Southern Group of State Foresters. Available online at www.southernforests.

org/documents/Regional%20BMP%20Report%202008.pdf; last accessed Dec. 9, 2009.

SIMPSON, H., J. DONELLAN, C. DUNCAN, AND S. HARRINGTON. 2008a. *Voluntary implementation of forestry best management practices in East Texas: Results from round 7 of BMP implementation monitoring 2007–2008.* Texas Forest Service, Lufin, TX. 38 p.

SIMPSON, H., D. WORK, AND S. HARRINGTON. 2008b. *Evaluating the effectiveness of Texas forestry best management practices: Results from the Texas Silvicultural BMP Effectiveness Monitoring Project 2003–2007.* Texas Forest Service, Lufkin, TX. 33 p.

SMITH, W.B., P.D. MILES, C.H. PERRY, AND S.A. PUGH. 2009. *Forest resources of the United States 2007: A technical document supporting the Forest Service 2010 RPA Assessment.* US For. Serv. Gen. Tech. Rep. WO-GTR-78. Available online at www.nrs.fs.fed.us/pubs/7334; last accessed Dec. 9, 2009. 336 p.

SOUTHERN GROUP OF STATE FORESTERS (SGSF). 2008. *Implementation of forestry best management practices: A southern regional report.* Southern Group of State Foresters, Water Resources Committee. Available online at www.southernforests.org/documents/Regional%20BMP%20Report%202008.pdf; last accessed Dec. 9, 2009.

VOWELL, J.L., AND R.B. FRYDENBORG. 2004. A biological assessment of best management practice effectiveness during intensive silviculture and forest chemical application. *Water Air Soil Pollut. Focus.* 4:297–307.

VOWELL, J., R. LIMA, C. HARDIN, G. MARCHALL, AND R. HOLLAND. 2008. *Results of Florida's 2007 silvicultural BMP implementation survey.* Florida Department of Agriculture and Consumer Services, Division of Forestry, Tallahassee, FL. Available online at www.fl-dof.com/forest_management/fm_pdfs/2007_bmp_survey.pdf; last accessed Dec. 9, 2009.

WELSCH, D., R. RYDER, AND T. POST. 2007. *Best management practices (BMP) monitoring manual—Field guide: Implementation and effectiveness for protection of water resources.* NA-FR-02-06, US For. Serv., Northeastern Area State and Private Forestry. 129 p.

WEYERHAEUSER COMPANY. 2009. *Current certification status.* Available online at www.weyerhaeuser.com/Sustainability/Footprint/CurrentStatus; last accessed Dec. 9, 2009.

ZIESAK, R. 2008. *Montana forestry best management practices monitoring: 2008 Forestry BMP audit report.* Montana Department of Natural Resources and Conservation, Forestry Division, Missoula, MT. 65 p.