PROGRAMS ASSESSING IMPLEMENTATION AND EFFECTIVENESS OF STATE FOREST PRACTICE RULES AND BMPS IN THE WEST

GEORGE ICE [1]*, LIZ DENT [2], JOSH ROBBEN [2], PETE CAFFERATA [3], JEFF LIGHT [4], BRIAN SUGDEN [4] and TERRY CUNDY [5]

[1] *National Council for Air and Stream Improvement, Inc., P.O. Box 458, Corvallis, Oregon 97339, U.S.A.;* [2] *Oregon Department of Forestry;* [3] *California Department of Forestry and Fire Protection;* [4] *Plum Creek Timber Company;* [5] *Potlatch Corporation*

(author for correspondence, e-mail: GIce@NCASI.org)*

Abstract. The major forest nonpoint source control programs in the West are largely regulatory, either under forest practices acts (California, Idaho, New Mexico, Nevada, Oregon, and Washington) or a streamside management act (Montana). These programs and the specific rules they enforce continue to undergo intensive scrutiny. Still, the questions are the same for these regulatory programs as for states that base nonpoint source control on voluntary BMPs (Arizona, Colorado, Utah, Wyoming). Are the rules or BMPs being applied, and are they effective in reducing nonpoint source pollution to levels that protect beneficial uses of water? The level of debate about forestry in the West has resulted in detailed monitoring and research to answer these questions. In the past, state agencies have assumed levels of BMP compliance based on the percent of operations without enforcement actions. These estimates are being replaced by statistically valid and reproducible monitoring of forest practices rules and BMP compliance levels. BMP effectiveness is being assessed using both qualitative and quantitative methods. This can involve field assessments, process-based research, and control watershed studies. Some trend monitoring is also beginning. With the regional implementation rate for forestry BMPs at about 94% and rising, it is likely that effectiveness testing will continue to be a priority and consume the majority of assessment resources for this region.

Keywords: BMPs, forest practices, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, water quality, Wyoming

1. Introduction

When the 1972 Water Pollution Control Act Amendments (later amended and renamed the Clean Water Act and hereinafter referred to as the CWA) became law only one state, Oregon, had a formal (albeit rudimentary) nonpoint source (NPS) control program for forestry. The CWA identified two types of pollution: point and nonpoint sources. Point sources are discrete discharges, such as sewage treatment plants. Nonpoint sources, such as those from most agricultural and forestry activities, are not traceable to any discrete facility or site, are usually best controlled through prevention rather than treatment, and are often induced by natural processes (e.g., runoff resulting from rain or snowmelt). Under the CWA, states were required to develop NPS control programs. In 1974 the U.S. Environmental

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Protection Agency (EPA) proposed that states adopt NPS control programs for forestry activities that were modeled after the forest practices acts of the Pacific Coast states (Rey 1980). This 'one-size-fits-all' approach was vigorously opposed and in 1977 EPA issued guidelines allowing either regulatory or voluntary NPS control programs if '... such programs were adequate to achieve desired water quality goals' (USEPA, 1977). As a result of this guidance and the unique conditions in each state, a variety of different types of NPS control programs, both regulatory and nonregulatory, would eventually be adopted. Still, the key measure of program success, laid out by the EPA 1977 guidance and the overall goals of the CWA, was whether the NPS control program could achieve desired water quality goals.

While different types of NPS control programs are adopted by states to achieve water quality goals, these programs all achieve reductions in water quality impact by requiring or encouraging the use of specific management practices known as Best Management Practices (BMPs). Best Management Practices are defined as 'a practice or usually a combination of practices that are determined by a state or designated planning agency to be the most efficient and practicable means (including technological, economic, and institutional considerations) of controlling point and nonpoint source pollutants at levels compatible with environmental quality goals' (Helms, 1998). For forestry, these BMPs can include streamside management zones, specific road construction and maintenance practices, appropriate timber yarding methods, careful application and handling of silvicultural chemicals, and a variety of other practices, all designed to protect water quality. In states with forest practices acts, the forest practice rules (and implementing process) are the state BMPs.

Program success can be largely assessed by two measures: when BMPs are applied do they reduce impacts so that desired water quality goals are achieved and are BMPs being used? In the South, where many states developed nonregulatory programs, the first questions that EPA and states raised were about BMP implementation levels. Do operators and landowners routinely apply BMPs and are implementation rates different than those found for regulatory programs? In the West, the questions were more about whether BMPs were effective in controlling NPS impacts. Efforts to measure the effectiveness of BMPs are not straightforward. When we discuss controlling BMPs it is recognized that NPS pollution cannot be completely eliminated yet can be reduced to an acceptable level. But water quality goals have become a moving target. Initially, BMPs were considered effective if they reduced gross water quality impacts to achieve the fishable and swimmable goals of the CWA. Early forest practice rules had language like, 'maintain riparian shade where possible'. These rules have continued to evolve, becoming more prescriptive about performance measures (e.g., percent of shade that must be maintained) and incorporating new findings about NPS impacts (e.g., maintain trees of sufficient size, species, and location for recruitment of large woody debris). While the ability to achieve water quality standards is often considered the ultimate

measure of BMP effectiveness, researchers are now finding that sometimes water quality standards cannot be achieved even for the least-impaired forest streams (HDR, 2002; Ice, 2002; Ice and Binkley, 2003). Therefore, the fishable/swimmable goals of the CWA or protection of beneficial uses of water becomes the most relevant water quality goals for assessing BMP effectiveness (ODF and ODEQ, 2002).

Of course over time, both these questions, implementation and effectiveness of BMPs, need to be answered to evaluate whether a state NPS control program is achieving desired water quality goals. Here we describe efforts in the 11 contiguous western states (Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming) to assess BMP implementation and effectiveness. This review does not address management on federal lands that occupy much of the forestland in the western region, focusing instead on programs for private forest operations. While we address all 11 states in this region, this review further focuses on the programs of California, Idaho, Montana, Oregon, and Washington, where the majority of commercial forest operations occur.

2. Individual State Reviews

The reviews for individual states cover a brief description of the state forest conditions (acres, growing volume, harvest level), the NPS control program for silviculture, and efforts to assess the implementation or effectiveness of BMPs. Land and timber statistics for the states for 2002 are available on the USDA Forest Service web site (USDAFS, 2002). These reviews are not meant to be comprehensive, but rather an introduction to further information about state programs. Contact information and links to additional descriptions of individual state NPS control programs for forestry are available on the worldwide web at http://www.usabmp.net.

2.1. ARIZONA

Nearly 60% of the forestland in Arizona is in public ownership (e.g., National Forest) and additional large tracts are in tribal ownership. Even though there are 19 million acres of forest in the state, the timber growing stock volume and harvest levels are very low. The state relies mainly on USDA Forest Service standards and guidelines, and tribal forest management programs to ensure that silvicultural operations protect water quality. Forestry is generally ranked a low-priority water quality issue for the state. Silviculture was not even listed as a probable source of stress to Arizona streams in the draft 2000 305(b) report and silviculture was ranked only the twelfth leading source of impairment to lakes in Arizona. No review of BMP implementation or effectiveness has been conducted.

2.2. CALIFORNIA

California had the third highest timber harvest level (628 million ft^3) of the 11 western states in 2002. There are more than 40 million acres of forest in the state and like Arizona, nearly 60% is public land. California's modern Forest Practice Act (FPA) was adopted in 1973, with full field implementation occurring in 1975. Under this Act, Timber Harvesting Plans (THPs) for commercial timber harvesting on all nonfederal timberlands must be submitted to the California Department of Forestry and Fire Protection (CDF). THPs are reviewed for compliance with the FPA and the Forest Practice Rules (FPRs) adopted by the California State Board of Forestry and Fire Protection (CSBOF), as well as other state and federal regulations protecting watersheds and wildlife. CDF, along with other state agencies (Department of Fish and Game, California Geological Survey, and Regional Water Quality Control Boards), conducts Pre-Harvest Inspections (PHIs) of proposed harvest areas to determine if plans are in compliance with the Act and FPRs. During PHIs, additional mitigation beyond the standard rules is usually recommended based upon site-specific evaluations. CDF also conducts field inspections during active timber operations and postharvest inspections when logging is completed.

Many monitoring efforts have been conducted during the past two decades to learn more about the implementation and effectiveness of FPRs in protecting water quality. These efforts complement the CDF Forest Practice compliance inspection program that has been in place for more than 25 years. A qualitative assessment of forest practices was conducted in 1986 by a team of four resource professionals who audited 100 completed THPs distributed throughout the state. The team found that the rules were generally effective when implemented on terrain that was not overly sensitive, and that poor rule implementation was the most common cause of water quality impacts (CSWRCB, 1987). Several changes to the FPRs were recommended based on the observations. Another example is the Critical Sites Erosion Study (Durgin *et al.*, 1989; Lewis and Rice, 1989), which collected extensive data on management and design factors associated with mass wasting events.

In 1988, CSBOF formed an interagency task force to develop a long-term monitoring program (LTMP) that could test the implementation and effectiveness of FPRs in protecting water quality. The resulting LTMP has implementation and effectiveness monitoring components, and a pilot project was used to develop appropriate techniques for both hillslope and instream monitoring (CSBOF, 1993). The Pilot Monitoring Program was completed during 1993 and 1994, with final reports written in 1995 (Tuttle, 1995; Rae, 1995; Spittler, 1995). The Hillslope Monitoring Program (HMP) pilot project developed methods for measuring rule implementation and effectiveness by modifying previously developed USDA Forest Service hillslope monitoring forms (USDAFS, 1992) and preparing new forms for practices that are unique in the FPRs (Tuttle, 1995).

The HMP has been conducting statewide evaluation of the implementation and effectiveness of Forest Practice Rules since 1996 using an annual random sample

of 50 completed THPs that have over-wintered from one to four years. Detailed information is collected from sampled plans in the summer months and includes data on: (1) randomly located road, skid trail, and watercourse and lake protection zone (WLPZ) segments, as well as randomly located landings and watercourse crossings; and (2) large erosion events (e.g., mass wasting features) where they are encountered. Winter documentation of fine sediment delivery to streams is not undertaken with this program. The monitoring work is done by highly qualified independent contractors who act as third party auditors by collecting field data and entering them into an extensive database. A report of interim findings was prepared in June 1999, and an updated report based on the first 300 projects was completed in 2002 (Cafferata and Munn, 2002). This is an ongoing program. Data collected as part of the HMP from 1996 through 2001 show that implementation rates of the FPRs related to water quality are high (averaging 94%) and that individual practices required by the rules are effective in preventing hillslope erosion when properly implemented. Implementation of applicable rules at erosion sites was nearly always found to be less that that required by the FPRs. Roads and their associated crossings have been found to have the greatest potential for sediment delivery to watercourses (CSBOF, 1999; Cafferata and Munn, 2002). These conclusions were similar to those reached in the earlier audit of 100 THPs (CSWRCB, 1987).

Beginning in 2000, an additional monitoring component was added by CDF to evaluate Act and rule compliance and effectiveness. The goal of Modified Completion Report (MCR) monitoring is for CDF's own Forest Practice Inspectors to monitor a random selection of 12.5% of all completed THPs for implementation and effectiveness of the FPRs related to water quality protection. For each THP evaluated, a randomly selected road segment, Water Course and Lake Protection Zone (WLPZ) segment, and two watercourse crossings are rated for FPR implementation at the time logging is completed. Effectiveness of erosion control facilities and crossing design and construction are rated a second time for the same road segment and crossings during an Erosion Control Maintenance inspection after one to three over-wintering periods. This monitoring process is providing data that complements the more detailed information supplied by the HMP.

Over 7,000 CDF Forest Practice inspections are completed each year on about 700 THPs, along with numerous other types of projects (timberland conversions, nonindustrial management plans, exemptions, etc.). These inspections are the major tool utilized by CDF to determine if timber operations are in compliance with the Act and rules. Water quality violations are corrected when and where possible as part of the normal Forest Practice Inspection process. A query of CDF's Forest Practice Program Database to determine the frequency of FPR violations issued for rules related to water quality from 1998 to 2000 found 975 violations were identified from the 4,749 THPs open during that period. These violations can be separated into three basic groups: harvesting practices and erosion control (347), watercourse and lake protection (308), and logging roads and landings (320). The FPRs with the highest number of violations generally involved waterbreak

rules, timber operations in the winter period, proper removal of temporary crossings, roads and landings located outside of WLPZs, removal of debris from very small watercourses, WLPZ trees felled away from the watercourse, removal of accidental depositions in watercourses, crossings open to unrestricted passage of water, size/number/location of drainage structures adequate to minimize erosion, and crossing removal adequate to prevent erosion. This type of information complements the data from the HMP and MCR monitoring work. Together, these three independent data sources allow cross-checking and corroboration of the results of each type of monitoring.

Determining which rules have the poorest implementation and effectiveness and the highest frequency of violations both provides input to the CSBOF on needed rule changes and identifies training needs for: (1) CDF's Forest Practice Inspectors; (2) Registered Professional Foresters (RPFs) submitting THPs; and (3) Licensed Timber Operators (LTOs). As an example of how the monitoring data have been used, the CSBOF adopted rule language in 2000 requiring RPF supervision of active timber operations based on information provided by the HMP and Ligon *et al.* (1999). In terms of training needs identified by monitoring, workshops on proper watercourse crossing design, construction, and maintenance were held in 2003.

Another important ongoing project that allows the state to assess rule effectiveness is the Caspar Creek Watershed Study conducted by CDF and the USDA Forest Service Pacific Southwest Research Station. This study provides research-level data on how forest practice operations prior to and after the implementation of the FPA have affected water quality (Ziemer, 1998; Cafferata and Spittler, 1998; Lewis, 1998; Lewis *et al.*, 2001; Ziemer, 2001). This study shows that modern FPRs have successfully reduced water quality impacts. Selective tractor logging and roading along the stream in the South Fork prior to implementation of the FPA was found to have increased suspended sediment yields 2.4 to 3.7 times over those measured with clearcutting and cable logging operations in the North Fork conducted under the modern FPRs (Lewis, 1998; Ziemer, 2001). Numerous landslides were documented after road construction and logging in the South Fork, while the size and number of landslides through 1998 were similar in logged and unlogged units in the North Fork (Cafferata and Spittler, 1998). CDF and the USDA Forest Service Pacific Southwest Research Station have signed a 100-year agreement for continuation of research at Caspar Creek. New streamflow and sediment monitoring stations with recording turbidimeters have been installed in nine tributaries of the South Fork to characterize hydrologic conditions prior to further second-growth harvesting. This ongoing research will allow for additional comparison of water quality and aquatic habitat impacts with and without application of the current FPA regulations. More than 100 papers and reports for the Caspar Creek Watershed Study are available at http://www.rsl.psw.fs.fed.us/projects/water/caspubs.html.

2.3. COLORADO

There are nearly 22 million acres of forest in Colorado but almost two-thirds of these are public lands. Forest inventory data (USDAFS, 2002) shows substantial growing stock volumes in the state, however growth and harvest rates are very low. Colorado has new BMPs for forest operations known as forest stewardship guidelines. These guidelines were adopted in 1998 and are outlined in a booklet adapted from Montana (CSFS, 1998). The state has been active in education outreach, largely through the Central Rockies Sustainable Forestry Education Program (other participating states are Wyoming and South Dakota) that involves a 30-hour course on forest BMPs and other issues. The state has used anecdotal feedback on BMP implementation through these workshops but has not conducted a formal survey to determine implementation. The Colorado State Forest Service is working with the Colorado Timber Industry Association to secure funding for a statewide audit of BMP implementation The state has also established multiple station water quality monitoring in two managed forest watersheds to track long-term water quality trends. These are actively managed watersheds that were selected to provide some feedback on responses to the new BMPs.

2.4. IDAHO

Idaho has 21 million acres of forest and supports the fourth highest harvest levels of the western states. Public ownership represents 84% of the forest land. Under the State of Idaho Forest Practices Water Quality Management Plan (Bauer *et al.*, 1988), the state is required to evaluate the implementation and effectiveness of state forest practice rules. There are two primary mechanisms for formally evaluating implementation and effectiveness. First, the quadrennial (once every four years) Forest Practices Water Quality Audit is led by the Idaho Department of Environmental Quality. Second, an annual (except on quadrennial audit years) Best Management Practices Internal Audit is conducted by the Idaho Department of Lands and the USDA Forest Service.

Initially, these evaluations focused primarily on implementation. Implementation rates have increased over the years from approximately 85% during the first survey to 96% in the 2000 Forest Practices Water Quality Audit (Hoelscher *et al.*, 2001). The implementation rates are not strictly comparable over time because the focus of the audits changes at the recommendation of the Forest Practices Act Advisory Committee. For example, the main focus of the 1996 audit was sediment delivery to streams, while the 2000 audit evaluated stream protection zones more closely.

In recent years, evaluations of effectiveness have become a larger part of evaluation processes. In the 1996 audit (Zaroban *et al.*, 1997), a simple yes/no evaluation was made on the question, 'Was sediment delivered to the stream from this forest practice?' No effort was made to quantify the amount of sediment or to evaluate the effects of the sediment on water quality and fish habitat. In a 1999 Forest Practices

Water Quality Audit (Colla and DuPont, 2000), the effort focused on habitat quality for bull trout in unharvested 'reference' and recently harvested sites. The 2000 Forest Practices Water Quality Audit (Hoelscher *et al.*, 2001) evaluated canopy cover, large woody debris, and fish passage at culverts (among other things). These audits generally show that the forest practice rules are effective. Zaroban *et al.* (1997) reported, 'On an individual rule basis, we found that when properly implemented and maintained, the practices described in the forest practice rules were effective 99% of the time'. However, they go on to say:

> We also found that half of the timber sales we audited had sediment being delivered to streams or stream channels as a result of forest practices activity. This apparent inconsistency can be attributed to management practice design, construction, maintenance, rule interpretation and other factors. The impact of this sediment delivery on the beneficial uses of the streams within these sale areas was not assessed.

Colla and DuPont (2000) wrote, 'This audit reaffirms what has been learned in past department and interagency audits. If the BMPs or rules are correctly implemented, they appear to be effective at minimizing or avoiding impacts to affected resources'.

Although these forest practices audits are not designed to directly determine the impact of sediment or other nonpoint source pollutants on beneficial uses, Idaho is responding to impaired waters listed under CWA §303(d) utilizing the Beneficial Use Reconnaissance Program (BURP). Like all states, Idaho is required to develop a list of waters not meeting water quality standards and develop Total Maximum Daily Load (TMDL) assessments to set load (point) and waste load (NPS) allocations that will achieve water quality standards and protect beneficial uses. BURP uses field measurements of water quality, stream habitat condition, and aquatic organisms to determine if beneficial uses are protected or impaired. Many forest stream reaches assessed using BURP were found not to be impaired.

Hoelscher *et al.* (2001) concluded that existing road and skid trail erosion control rules were both well implemented and effective. They did, however, have concerns about leave tree and shade requirements in stream protection zones. The latter issues are currently being addressed within the Forest Practices Act Advisory Committee and some rule changes are expected.

In addition to these state efforts, the effectiveness of the state forest practice rules is being tested by Potlatch Corporation and cooperators at Mica Creek in northern Idaho. The Mica Creek watershed project, initiated in 1990, represents a major paired and nested watershed test of forest practice impacts. The study design was inspired by the Caspar Creek Watershed Study in California and allows researchers to measure cumulative impacts. The 29 km^2 study area includes paired watersheds at three different scales. After a calibration period, road construction effects were monitored, and monitoring is continuing to document the effect of timber harvesting in 2002 (McGreer *et al.*, 1995; Cundy *et al.*, 2001). Results from Mica Creek are just beginning to be reported (Ice *et al.*, 2002).

The adaptive management or continuous improvement model adopted to implement the Idaho Forest Practices Act in 1974 and the audit processes required under the 1988 Water Quality Management Plan work well. Data are collected on a regular basis, results are analyzed, and adjustments are made to rules. With the flexibility to focus evaluations on areas of high concern, all stakeholders can be assured that the program resources are used to understand and address the most relevant current issues.

2.5. MONTANA

Montana has 23 million acres of forest, three-quarters of which are in public ownership. In 2002 it had the fifth largest timber harvest of the 11 western states. Prompted by increasing public concern about timber harvesting impacts on water quality, the 1987 Montana Legislature directed the Montana Environmental Quality Council (EQC) to examine how current forest practices were affecting watersheds, and summarize what options existed to better control the impacts. The EQC is a legislated working group composed of elected state representatives, as well as governor-appointed citizen members (Montana Code Annotated [MCA] 5–16–101). It is periodically tasked by the legislature to work on environmental issues during the 2-year period between state legislative sessions (MCA 75–1-324). The final report (EQC, 1988) found that BMPs were properly applied 82% of the time, and that management of streamside areas and road erosion received the lowest overall ratings. Recommendations from their report (EQC, 1988) precipitated several changes in Montana's nonpoint source management program for forestry, including formation of a Technical Committee to guide development of a set of statewide forestry BMPs. This committee included industrial and nonindustrial landowners, logging contractors, Montana Water Quality Bureau staff, representatives of the USDA Forest Service, and was led by the Montana Department of Natural Resources and Conservation (DNRC).

In July 1989 the BMP Technical Committee finalized a consistent set of voluntary statewide forestry BMPs, which were updated in 1997. These BMPs are contained within the state Nonpoint Source Management Plan (Montana DEQ, 2001). Also in 1989, the Montana Legislature enacted a law requiring landowners to notify DNRC of plans to initiate a forest practice (MCA 76–13–131) in advance of operations ($\sim$1300 notices per year statewide). The DNRC then distributes information to the landowner on state forestry BMPs and information on stream crossing permits that may be needed from the local Conservation District. If a proposed activity is in an area of high priority for watershed conservation, or there are other watershed concerns, the DNRC may require an onsite visit with the landowner by a state service forester ($\sim$140 onsite visits per year). Notifications also allow the state to maintain a database of the amount and location of harvesting, which serves as the basis for BMP audit site selection.

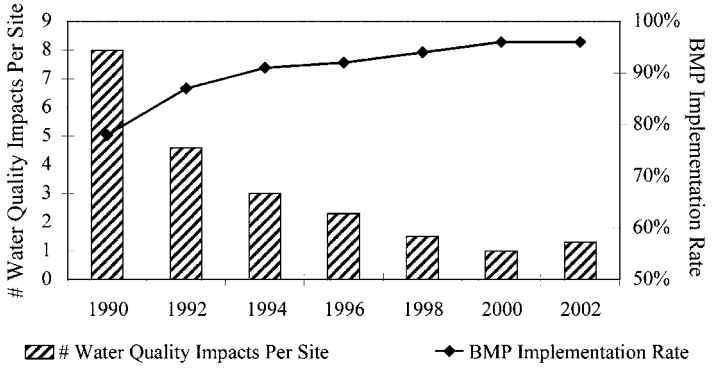

Figure 1. Montana BMP implementation rates for the period 1990–2002, and the number of observable water quality impacts per harvest site (Ethridge, 2003)

Streamside management zones (SMZs) had been found in 1988 to be areas of lower BMP compliance. In 1991, the state legislature passed a law governing commercial harvesting in streamside areas (Streamside Management Zone Act, MCA 77–5–301). This act requires 50- to 100-foot partial retention buffers along all streams, depending on sideslope steepness. Numerous other prohibitions exist within the SMZ, including streamside road construction, broadcast burning, depositing road fill, hazardous chemical application, and equipment operation.

BMP compliance in Montana has been monitored biannually since 1990. Audits are coordinated by the Montana DNRC, but audit team membership consists of resource professionals from state and federal agencies, the forest products and logging industries, environmental community, and other volunteers. Four interdisciplinary teams audit a total of 40 to 45 sites. Teams include a forester, road engineer, hydrologist, soil scientist, fisheries biologist, a small private landowner or logger, and someone from the environmental community. To qualify for the audit, harvest areas must contain an SMZ, have road construction, use tractor logging on steep slopes, or in some other fashion be considered higher risk. Requiring road construction and/or SMZs in the harvest area allows for the full range of BMPs to be rated. From this available pool, audit sites are randomly selected for different ownership categories and regions of the state (in proportion to the amount of harvest).

Results since 1990 show continued improvement in statewide BMP implementation rates (Figure 1). Statewide application of BMPs in 1990 averaged 78%. By 2000, this had improved to 96% (Ethridge and Heffernan, 2001; Ethridge, 2003). Additionally, the 2000 audit found that regulatory SMZ law requirements were met 96% of the time. Improvements in BMP implementation have occurred across all ownership categories and geographic regions of the state.

The steady pace of improvement is attributed to logger education efforts by the Montana Logging Association and Montana DNRC, which typically reach 250 loggers each year. Small private landowner education has also improved through the

Montana Forest Stewardship Program administered by Montana State University Extension. This program has resulted in forest management plans on 750,000 acres to date, or about one-quarter of the nonindustrial private forestland in Montana. Improvements on industrial private lands have resulted from corporate management placing a high priority on environmental compliance.

The audit process itself has proven to be a major educational tool. In addition to foresters, loggers, road builders, and others connected with harvest usually participate as observers. Having the folks that do the work on the ground exchange ideas with the audit teams proves to be a tremendous learning experience. The audit report is widely distributed to everyone in the forest products industry. The most problematic BMPs are distilled into a 'top ten list' which helps focus everyone's educational effort.

Evaluation of BMP effectiveness is addressed qualitatively during the BMP audit process. Each BMP rated for application is also assessed for its effectiveness in preventing visible erosion and/or sediment delivery to streams (as evidenced by gullies or sediment paths). While subjective, these assessments are believed to yield important information that may not be deduced by instream methods (Corner *et al.*, 1996). The frequency of observable water quality impacts (sediment delivery to streams) has decreased dramatically as BMP implementation rates have increased (Figure 1).

Currently, there is no coordinated statewide agency program in place for comprehensive research investigations to examine BMP effectiveness. Plum Creek Timber Company, the state's largest industrial timberland owner, is conducting the most extensive BMP effectiveness research as part of its Native Fish Habitat Conservation Plan (Plum Creek Timber Company, 2000). This research includes investigations of reach- and watershed-scale effects of streamside timber harvesting on water temperature, and effectiveness of road improvements in reducing fine sediment delivery to streams and improving spawning gravel quality. Plum Creek research also includes validation of assumptions used in large woody debris recruitment and sediment models. The state DNRC is initiating some effectiveness monitoring as part of its State Forest Land Management Plan.

2.6. NEVADA

While Nevada is reported to have 10 million acres of forest it supports by far the lowest growing stock volumes and timber harvest volumes of the 11 western states. Despite the low level of forest management, silvicultural activities in Nevada are strictly regulated by the Nevada Forest Practices Act (NFPA) and the State Diffuse Source Law. Under the NFPA a timber harvest permit from the state is required to conduct harvest operations. This involves a timber harvesting plan (utilizing BMPs) and a performance bond to ensure satisfactory compliance. Commercial timber harvesting is minimal in the state, averaging about three or four sales a year. These activities are almost always near Lake Tahoe and are subject to intense scrutiny.

Timber harvests in this area are also subject to regulation by the Tahoe Regional Planning Agency (TRPA) and must adhere to TRPA rules. As a result there have been no defaults on the performance bonds in recent years. An emerging issue is the development of BMPs for harvesting pinyon-juniper forests for biomass recovery and to restore wildlands (wildfire hazard reduction and reduced evapotranspiration stress).

2.7. New Mexico

New Mexico has 16.6 million acres of forest but harvest levels are low. Public lands comprise 62% of the forest. New Mexico has a forest practices act and adopted revised forest practice rules in January 2002 (http://www.nmforestry.com). Timber harvest plans are required for operations of 25 acres or larger. Forest practice rules are still required on smaller operations. Implementation of the rules was estimated to be 75% (Ice and Stuart, 2001), based on the inspection reports required for each timber harvest plan, however this is probably an underestimate of the current level of compliance. A statewide database for these inspections is not currently available but is planned. Once the implementation database is operating the state plans to explore opportunities to test the effectiveness of the rules.

2.8. Oregon

Oregon has historically been the leading timber producing state in the United States but has recently slipped due to reduced harvests on federal forest lands. The state has 29.6 million acres of forest and 63% of these are public. Still, annual harvest levels are near the top, not only for the west but the entire United States. The Oregon Department of Forestry (ODF) regulates forestry operations on nonfederal land. Landowners and operators are subject to the Forest Practices Act (adopted in 1971) and rules when any commercial activity relating to the growing or harvesting of trees is conducted. The Oregon Board of Forestry has exclusive authority to develop and enforce statewide and regional rules. The Board believes continued monitoring and research is necessary to provide information about the adequacy of the Oregon Forest Practice Act (FPA) and rules and how to improve them. The Oregon Department of Forestry's Forest Practices Monitoring Program (FPMP) provides scientific information for adapting regulatory policies, management practices, and volunteer efforts on nonfederal forest land.

The FPMP is responsible for monitoring the implementation and effectiveness of the rules and reporting those findings and recommendations to the Board of Forestry on an annual basis. These rules are subject to revision as necessary based on the best available science and monitoring data. The rules have undergone many revisions since 1972. The most recent changes to the water protection rules were in 1994 and 1995. The FPMP conducts a variety of projects designed to assess how well current rules are achieving the desired goals (effectiveness monitoring) and the rate of rules implemented in the field (compliance monitoring). What follows

is a summary of two of ODF Forest Practices monitoring projects; one focusing on effectiveness and the other on compliance.

In 1994 new rules were adopted to maintain and promote *desired future riparian stand conditions* that will provide ample shade, an abundance of large wood to the channel, bank stability, snags, nutrient input, and nutrient uptake. These rules require the establishment of Riparian Management Areas (RMAs) on most streams that are within or adjacent to a harvest unit. The RMA width requirements vary depending on the stream classification. ODF classifies streams by 'Type' (fish-bearing, domestic water source, non-fish-bearing) and by stream size. A landowner has multiple options for managing RMAs. The objectives of this monitoring project were to determine if the forest practice riparian rules promote riparian conditions that are consistent with levels observed in mature riparian forests and if the rules are effective at maintaining structure that will promote the desired future conditions for large wood recruitment and shade.

The study used pre- and postharvest comparisons of riparian function and structure to evaluate harvest effects. It was conducted at volunteered sites distributed throughout the state of Oregon. A detailed field protocol is available from ODF (http://www.odf.state.or.us/internal.htm). Results indicate substantial variability in conifer stocking within and between georegions and stream sizes. Basal area standard targets were commonly met within 20 ft of the stream on small (72% of sites) and medium (81%) streams. Under such circumstances a landowner would have the option to clearcut harvest to within 20 ft of the stream. However, results also indicate that, in most instances, landowners are not exercising this option.

Both shade and large wood recruitment potential were reduced on small and medium streams as compared to preharvest conditions. Results indicate that stand characteristics of these riparian forests vary greatly across the landscape, making a single regulatory goal problematic. However, it appears the current rules underestimated the prevalence of conifer trees within the first 20 ft of small and medium streams, thereby underestimating the amount of coniferous basal area that is available on these streams. Recommendations were made to the Forest Practices Advisory Committee to increase conifer leave tree requirements along small and medium streams. A final report is available (Dent, 2001).

The ODF Forest Practices Monitoring Program implemented the BMP Compliance Monitoring Project (BMPCMP) to evaluate compliance with the rules on nonfederal forestland. The first year of the project (1998) was a pilot study used to revise the site selection and data collection protocols, determine the needed sample size, and provide preliminary compliance results. During the 1999 and 2000 field seasons, the final version of the BMPCMP was implemented. The goal of the BMPCMP was to identify the level of forest operations in compliance with the Forest Practice Rules based on a statistically reliable sample and to determine if adjustments to administration of the program are needed, such as areas where forest practice rule language can be clarified, administration of the rules can be improved, or additional education and training are needed.

A total of 189 harvest operations associated with streams and wetlands were surveyed for this project. Operation units were randomly selected and stratified statewide to account for regional differences in the numbers of notifications and types of practices implemented; differences between industrial, nonindustrial, and other (generally government) landowners; and heightened concern for fish-bearing streams. Site selection was done so that the sample distribution was proportionate to that of the total population of 1998 notifications. The exception to this was an intentional bias towards the selection of units associated with fish-bearing (Type F) streams in order to better assess those rules which would apply only to these sensitive and valued resources. The weakness of this stratification is that it may undersample steep terrain, as steep units are less likely to have Type F streams.

At selected harvest unit sites, practices and features within that unit (harvest practices, roads, skid trails, riparian management areas, wetlands, etc.) were evaluated for compliance with 150 Forest Practice Rules designed to protect water quality and fish habitat. Each unit was surveyed by a former Forest Practices Forester who evaluated all individual BMP applications as either 'compliant' or 'noncompliant'. To view the detailed protocol for this project, visit http://159.121.125.11/FP/fpmp/default.htm. Stream crossing structures (bridge, culvert, or ford) were evaluated for fish passage and 50-year stream flow event capacity using a separate selection process and field protocol. These results are discussed in a report titled *Oregon Department of Forestry: Compliance with Fish Passage and Peak Flow Requirements at Stream Crossings, Final Study Results* (Paul *et al.*, 2002). The stream crossing protocol and final report can be found online at the website listed above. A total of 13,506 BMP applications were reviewed on the 189 harvest operations. The overall compliance rate for these applications was 96.3%. The compliance rates for all rule applications within each rule division are shown in Table I.

There were ten specific practices identified as having the most significant compliance issues (<96% compliance and five or more noncompliant practices). These were slash piling within stream channels and wetlands, removal of petroleum-related waste from the unit, stream crossing fill stability, road surface drainage, felling of trees into small Type N streams, skid trails near streams and wetlands, removal of temporary crossings, protection of other wetlands, prior approval requirements, and written plan requirements. Of the 502 total noncompliant practices surveyed, 185 (37%) were with administrative requirements not directly affecting riparian and channel conditions, 147 (29%) had the potential to impact riparian and channel conditions in the future, and 170 (34%) had an observed impact to riparian and channel conditions. In order to help achieve the highest possible level of BMP compliance, the results of this project are currently being presented to landowner groups, operator workshops, and department conferences. These results are also being used to clarify guidance language, develop additional implementation tools, and guide future monitoring needs.

TABLE I
Compliance rates for Oregon forest practices rule categories

Section description	Compliance rate
Reforestation (riparian management area reforestation only)	100.0%
Treatment of slash	98.2%
Chemicals and petroleum products	94.3%
Road construction and maintenance	97.6%
Harvesting	98.1%
Vegetation retention along streams	96.4%
Protection measures for significant wetlands	88.1%
Protection measures for other wetlands	69.8%
Protection measures for lakes	N/A
Operations near Waters of the State (WOS)	100.0%
Administrative requirements	83.0%

These examples represent just two of the FPMP activities. Additional studies have been implemented to evaluate riparian function, stream temperature, chemical applications, reforestation, and sediment delivery from forest roads. The complete Forest Practices Monitoring Program Strategy (Dent, 2002) can be viewed at http://159.121.125.11/FP/fpmp/default.htm.

Two other forest practice rule assessment efforts in Oregon deserve note. A number of forest industry and agency cooperators are just beginning calibration of paired watersheds in the Hinkle Creek Drainage in southwest Oregon to test the effectiveness of the current forest practice rules in protecting fish and water quality. Stream temperature, riparian habitat, and fish response are some of the response variables that will be measured. Also, since 1990 the Oregon Department of Fish and Wildlife (ODFW) has been working with forest landowners to collect information on stream habitat conditions as part of the Aquatic Inventory Project (AIP). This project has created a database representing 4,000 stream reaches throughout Oregon. With resurveys of the stream reaches, it is possible to assess trends in stream habitat conditions. The information has been organized by Oregon State University scientists into a GIS database with nearly 100 variables describing stream and habitat attributes (Wing and Skaugset, 1998). One additional program of note is the Headwater Research Cooperative that is supporting research on mostly non-fish-bearing forest headwater streams to assess how they function and appropriate management practices. Information on this cooperative is available at http://www.headwatersresearch.org.

2.9. UTAH

There are 15.7 million acres of forest in Utah but most forest land (82%) is in public ownership. Annual harvest levels are low. Utah has voluntary BMPs for private forest lands. These are referred to as Forest Water Quality Guidelines (FWQG). One of the earliest assessments of forest nonpoint source impacts in any state was conducted in Utah and published by the Division of State Lands and Forestry (Hosking *et al.*, 1982). The assessment involved field surveys of 55 timber sales (less than 10 years old) that were selected on the basis of the '... potential to impact water quality'. The number of USDA Forest Service, state, and private sales surveyed was roughly proportional to the number of harvests conducted annually in the state. Of the 55 sales investigated, 16 exhibited '... noticeable adverse water quality impacts', but only 5 impacted '... water quality to a degree that remedial action should be considered'. Because state and federal harvests represent 92% of the harvest operations and FWQG are required on state lands and federal lands are carefully managed, it was concluded that silviculture is not a significant NPS in the state.

No assessments of the effectiveness or implementation rates for the FWQG have been conducted since the 1982 field survey; however, substantial changes have occurred and will occur in the near future. In 2001 the state legislature passed a forest practices act that requires registration of operators and notification by operators of plans to harvest timber. FWQG are still voluntary but the notification process will allow for education outreach to operators. A two-tiered FWQG monitoring program is being implemented. The first tier involves field audits of 100% of all sales involving state service foresters (FWQG field audits). The second tier will involve a periodic interdisciplinary team assessment of a subset of the timber sales in the state. This team assessment is being modeled after the Montana BMP survey.

2.10. WASHINGTON

Washington has 21.8 million acres of forests and nearly 60% of these lands are public. In 2002 Washington had the highest volume of harvest in the United States. Washington has one of the most heavily regulated forest management systems in the United States (Green *et al.*, 2000). Virtually all forest management activities are governed by the Forest Practices Act. Forest practices rules (FPRs) were established in 1975 and have been revised 13 times (Holter, 2001). The most significant improvements for BMPs relating to fish habitat and water quality protection occurred in 1987, 1992, and 2001. In 1987, the Timber, Fish, and Wildlife (TFW) Agreement was finalized. This agreement set forth goals, a framework, procedures, and requirements for cooperatively managing the state's private and state timberlands. Parties to the agreement included private landowners, Native American tribes, state agencies, and environmental groups. This rule change expanded the protection for riparian areas, cultural resources, and upland habitat for wildlife, increased regulations on use of forest chemicals, and broadened stakeholder

involvement in forest management. Interdisciplinary teams comprised of representatives from TFW stakeholder groups were frequently used in field reviews of forest practice applications.

In 1992, a cumulative effects assessment process was developed through the TFW program. This process, termed Watershed Analysis, was codified in the FPRs and became a means of developing basin-specific BMPs for the protection of fish habitat and water quality (Washington Forest Practices Board, 1997). By design, Watershed Analysis required an evaluation of BMP performance in the study basins. Subsequently many other states, provinces, and agencies have developed various watershed assessment and analysis methods and these often have elements that allow for assessment of practice effectiveness (Ice and Reiter, in press; Cook and O'Laughlin, 2000). At the same time Watershed Analysis was adopted, other revisions were made to the FPRs (e.g., wetlands and stream temperature protection, additional restrictions on forest chemicals and fertilizers, clearcut size and timing requirements).

The most recent revisions to Washington's FPRs occurred in 2001. These changes were prompted by common themes encountered in Watershed Analyses and the numerous listings of native salmonid fish species under the federal Endangered Species Act. The original TFW stakeholder group was expanded to include federal agencies (NMFS, USFWS, and EPA). Almost every facet of the FPRs was overhauled in this update. These rules are intended to satisfy federal requirements for protection of freshwater habitat for fish and other aquatic vertebrates under the Endangered Species Act, and for water quality under the Clean Water Act (DNR, 2002).

For the past 15 years, an important feature of Washington's forest management system has been the use of the adaptive management approach to guide BMP development. Adaptive management requires the collection of information for feedback on system performance. This spurred a series of research-level investigations of compliance and effectiveness of different types of practices. In 1991, the TFW Field Implementation Committee conducted a compliance survey (TFW, 1991). In this survey, 191 completed projects were randomly selected and field reviewed for rule compliance. Compliance varied from low for road maintenance and riparian timber harvest to high for road construction, yarding, site preparation, and hydraulic considerations. A follow-up study was conducted to more thoroughly investigate compliance with rules governing activities in and near riparian areas (TFW, 1994). In this study, 94 timber sales were randomly chosen from a sample of 1,708 forest practice applications (FPAs). Results showed generally high (>90%) compliance with operational rules (use of heavy equipment in riparian areas, slash disposal, etc.). Compliance rates were also high (81 to 100%) for riparian management zone width and tree count requirements in western Washington. Postharvest blowdown of trees left in riparian buffers was also qualitatively evaluated at 91 sites. Winds felled less than 10% of the leave trees at 82% of the sites. One site had >50% blowdown. Landowners often left wider buffers than were required by

law. The details of these studies provided information about the practices that were most prone to violations, and often led to changes in BMPs.

Aside from these detailed but sporadic studies of rule implementation, Washington has no program to document FPR compliance. However, the Department of Natural Resources (DNR), the state agency that administers the forest management system, does use procedures to foster implementation success. With limited resources and high volumes of FPAs, the DNR is forced to concentrate its efforts on the review and conditioning of FPAs that have the potential to significantly impact public resources (i.e., 30-day Class III and Class IV special FPAs). DNR's Forest Practices Foresters therefore expend considerable effort during the preapproval review phase of the FPA permitting system. In most DNR regions, a high proportion of these sensitive FPAs are scrutinized and reviewed in the field before approval to ensure the operations are properly designed for site conditions (Gary Gideon, DNR Forest Practices Division, personal communication). In addition, DNR's goal is to visit and evaluate compliance for at least half of Class III and all of Class IV special FPAs after the operations are completed.

The need for information on implementation success was recognized during the most recent rule negotiations. To measure and report compliance of the newly revised practices, DNR is charged with providing 'statistically sound, biennial compliance audits and monitoring reports' (WAC 222–08–035). To date, no program has been established or funded to complete this task. However, efforts are underway to measure effectiveness of the new rules and to validate some of the scientific underpinnings of the FPRs.

To study the effectiveness of forest practices and to monitor status and trends of public resources, the TFW Cooperative Monitoring, Evaluation, and Research Committee (CMER) was formed in 1987. Steering committees were organized by discipline to address different research areas. For example, the Water Quality Steering Committee sponsored a series of important studies on the effectiveness of forest practices affecting water quality. One of the first of these was a study of the adequacy of riparian rules for protecting stream temperatures (Rashin and Graber, 1992). This was followed by an evaluation of BMPs for aerial application of forest pesticides (Rashin and Graber, 1993), and finally by a study of the effectiveness of BMPs for controlling sediment impacts (Rashin *et al.*, 1999).

Other CMER steering committees have also sponsored BMP effectiveness studies. The Monitoring Advisory Group (MAG) initiated development of an effectiveness monitoring program (Schuett-Hames *et al.*, 1996). Several studies were subsequently conducted to evaluate the performance of Watershed Analysis prescriptions for riparian areas (Soicher, 1999a; Grizzel *et al.*, 2000) and unstable slopes (Soicher, 1999b). The Wildlife Steering Committee sponsored an ambitious study on the effectiveness of TFW riparian prescriptions for the protection of wildlife (O'Connell *et al.*, 2000). Projects to develop methods for effectiveness monitoring were also funded during this period (e.g., Pentec Environmental, Inc., 1991; Cupp *et al.*, 1999). Experience gained from these studies is being used to

develop the effectiveness monitoring program for the newly established FPRs. With several millions of dollars in federal funding to support research on salmon, CMER is now developing an ambitious research and monitoring program for the new rules. One of the key areas that CMER will focus on is non-fish-bearing headwater streams and their functions and impacts on receiving waters.

Like many other states, Washington is also interested in trend monitoring to determine long-term integrated responses to the forest practice rules. Washington began a trend monitoring program in 1989 that ended soon afterward when funding and interest waned. The effort was scaled back and revived in 1992. Modest data gathering efforts continued until the present (principally conducted by Native American tribes). Recently, a Monitoring Design Team has been developing a more durable trend program design and a draft of this program will soon be released.

2.11. WYOMING

Wyoming has 11 million acres of forests, second only to Nevada for lowest total in the west, and 83% of the forest is in public ownership. Harvest levels are very low. Wyoming has voluntary BMPs developed by the Wyoming State Forestry Division. In 2000/2001 a field audit based on the interdisciplinary team approach used in Montana was conducted on 12 timber harvest sites (Lee, 2002). Audit sites were biased toward those that had potential water quality problems or highly erodable conditions, including those in close proximity to running water or containing wetland and riparian drainage. The findings are that:

> ... most sales had one instance where the application or effectiveness of the BMP was inadequate. Overall, these departures were minor and did not cause erosion or deliver sediment to a waterway. On average, audited sales were found to meet or exceed the standard set forth in the BMP handbook on 91.4% of the total application points, and 93.3% of the total effectiveness points.

Practices commonly found to need improvement included construction of cross drainage, slash placement on skid trails (to divert and slow water), rolling dips for haul roads, construction of energy dissipaters, spacing of erosion control features, and SMZ designation.

3. Synthesis

A variety of NPS control programs are used in the west, some regulatory and others voluntary. In order to assess program effectiveness, most western states have invested in monitoring and testing of BMP implementation rates, the effectiveness of BMPs, or both. Overall, these studies show high rates of BMP implementation and the general effectiveness of state BMPs in protecting water quality. An example is Montana. Over a 10-year period, audit reports show that BMP implementation has increased from 78 to 96% and water quality impacts have decreased. Still, there

is unlimited skepticism about the effectiveness of forest nonpoint source control programs and limited assessment resources. For example, a National Public Radio commentary from the Executive Director, Montana Trout Unlimited, is critical of the Montana audit results:

> The audits routinely show BMPs are being used and that they are probably effective. But there's a catch. The audits are after-the-fact, snapshots-in-time estimates of whether practices affecting, say, road drainage or construction, were effective on small portions of randomly selected timber sales. The audits are subjective. The estimates [are] intuitive. Cause and effect is not measured. Scientific rigor is absent. Moreover, the audits occur during summer, when conditions are dry and vegetation leafed out, complicating guesses on how effective BMPs were during wetter periods. Has the timber industry made strides with BMPs? Unequivocally, yes. Can it do more to improve the balance between producing wood fiber and protecting the environment? Absolutely. Will that happen? It would be nice.

In Oregon, with the oldest of the silvicultural nonpoint source control programs, the Pacific Rivers Council has filed a lawsuit against the Board of Forestry (*Pacific Rivers Council et al. vs. James Brown*), alleging that the rules result in take of coho salmon in violation of the federal Endangered Species Act. Regionwide there are efforts to increase regulation of harvesting near small, non-fish-bearing streams, and certain practices like clearcutting and the use of silvicultural chemicals are an anathema to many, thus precipitating public referendums.

This level of skepticism about the results of BMP audits and monitoring may be why states like Oregon, Washington, and California (where skepticism is the greatest) spend substantial funds and time developing protocols for rigorous, scientifically defensible assessments of BMP effectiveness and implementation. There are also redundant assessment approaches used in these states, from basic inspection statistics, enforcement data, interdisciplinary team reviews, and survey studies to more detailed research projects.

It is unlikely that any single state can support all the assessment studies needed to evaluate the effectiveness of state BMPs and implementation rates. Instead, the aggregate regional results must be used. States like Montana, Idaho, and Wyoming can say that they have surveyed BMP compliance and effectiveness and can track trends, but these audit assessments are somewhat subjective. Extensive inspection or enforcement records provide for statewide coverage and trends in Oregon, Washington, and California but are, again, somewhat subjective. Detailed watershed studies in California (Caspar Creek), Idaho (Mica Creek), Washington (Watershed Analysis), and soon in Oregon (Hinkle Creek) allow for rigorous and scientifically defensible testing of the state BMP package, but just for one watershed and one weather pattern. Detailed tests of riparian rules in Oregon, Montana, and Washington or the chemical rules in Washington and Oregon allow for a broader test of specific rules and adjustment of those rules, but these studies say nothing about the effectiveness of other rules. Quantitative evaluations of every possible

TABLE II

Summary of state silviculture NPS control programs showing states with BMPs, forest practice rules, BMP implementation rates, and presence and type of effectiveness studies

State	BMPs	FP rules	Impl. rate	Effectiveness
Arizona	Federal and tribal guidelines	No	Not applicable	No
California	Yes	Yes	92%	*Study*/survey
Colorado	Yes	No	No data	Trend
Idaho	Yes	Yes	92%	*Study*/survey
Montana	Yes	Yes	96%	Survey
Nevada	Yes	Yes	100%	NA
New Mexico	Yes	Yes	75%	Planned
Oregon	Yes	Yes	96%	*Study*/survey
Utah	Yes	No	No data	*Study*/survey
Washington	Yes	Yes	No data	*Study*/survey
Wyoming	Yes	No	91%	Survey

rule permutation is a daunting challenge. For example, there are an estimated 50 unique combinations of riparian prescriptions under Washington's new forest practice rules (Schuett-Hames and Conrad, 2002). Each assessment approach has its advantages and disadvantages, but put together regionally, we can say with confidence that BMPs are being implemented at a high rate, they are generally effective, and for some practices, particularly road sediment abatement BMPs, we have the regionwide data to prove it. Some uncertainty to this conclusion is created by the continuing evolution of water quality goals. For example, landslides used to be viewed as uniformly detrimental to water quality and fish habitat. Now landslides are seen as essential to maintaining stream functions and the debate focuses on the timing, size, and numbers of landslides affected by forest management.

A westwide assessment of silvicultural BMP implementation can be made from the rates reported by individual states (Table II). Adjusted for the acres of forestland in each state (USDAFS 2002) and using the so-called 'imputation method' of the United States census (estimated residents in nonreporting households based on average of residents in nearby households) for Colorado, Utah, and Washington, we calculate that the westwide BMP implementation rate is 94%. The trend data from Idaho and Montana indicate that this rate is increasing, although it will be difficult to make further significant gains. BMP implementation data can be especially useful in targeting specific practices that are underapplied.

All states except Arizona and Nevada report some effectiveness monitoring or plans to conduct effectiveness monitoring. These efforts continue to evolve from

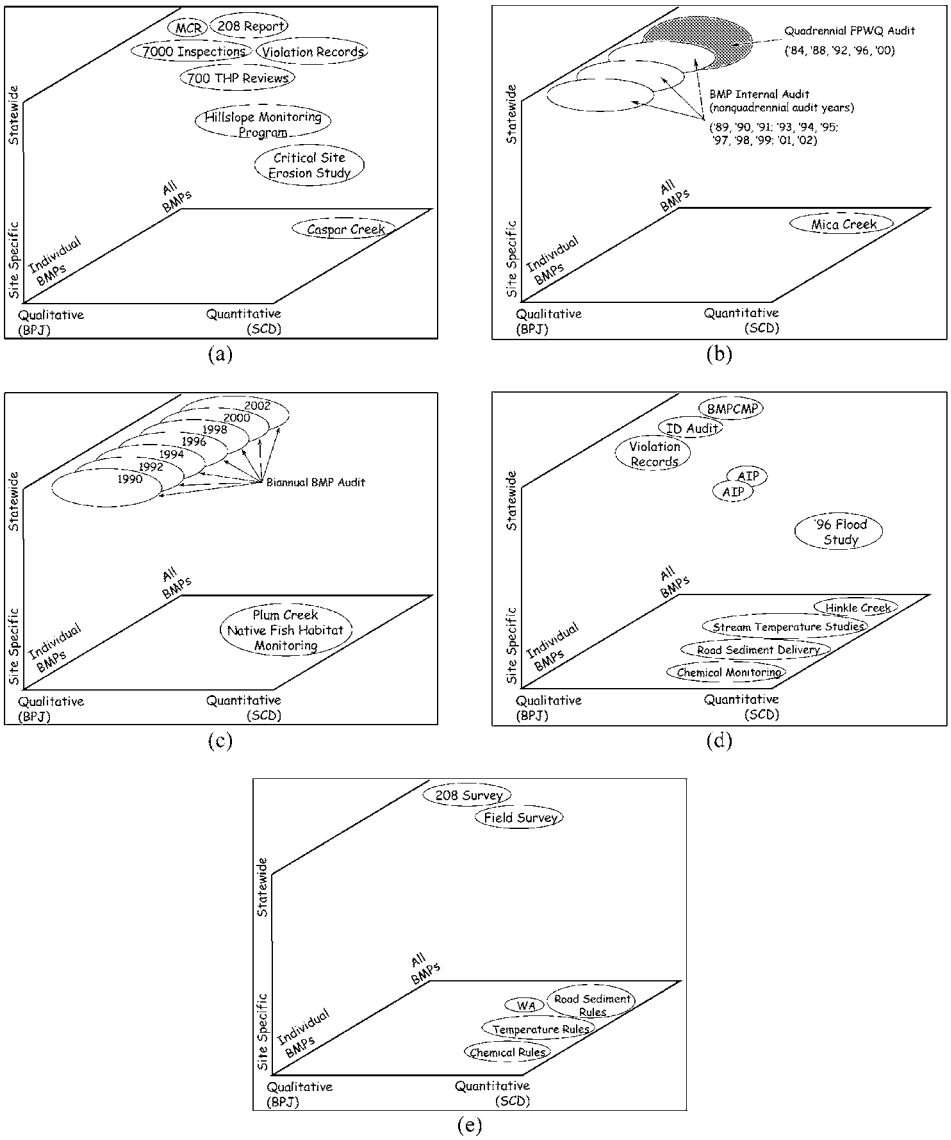

Figure 2. A dimensional depiction of the rigor (Best Professional Judgment [BPJ] or Scientifically Credible Data [SCD]), scope (individual BMP or all BMPs), and scale of area coverage (site specific or statewide) for effectiveness and implementation assessments carried out in the five key Western states of (a) California, (b) Idaho, (c) Montana, (d) Oregon, and (e) Washington.

qualitative assessments to rigorous and scientifically defensible tests of individual practice effectiveness. One way to look at how states are evaluating effectiveness is to depict the effectiveness studies in terms of assessment rigor, BMP coverage, and geographic coverage. Effectiveness assessments can range from qualitative, best professional judgment to scientifically defensible, with adequate controls to account for natural background response. Assessments can be focused on one or just a few individual practices or assess all the state rules or BMPs. Assessments can be isolated on single watersheds where more rigorous controls can be utilized or they can be carried out statewide across many different ecoregions. Figure 2 provides a qualitative three dimensional depiction of the various state assessments in these terms both for BMP effectiveness and implementation. It is the efficient mix of these approaches that provides the most return on investment in state progam assessments.

While assessments universally find BMPs effective in reducing impacts from forest activities, the performance standards and expectations for BMPs continue to change. There is widely recognized drift in assessments with increasing scrutiny about what is acceptable implementation and what is effective. Similarly, forest practice rules and BMPs continue to change, particularly for the West Coast states. This fluid combination of changing expectations and changing rules necessitates ongoing testing of effectiveness. This also means that states need to frame their monitoring and research projects to measure fundamental watershed responses to a continuum of management practices that can be applied universally to the region (e.g., minimum buffer widths needed to protect stream temperatures). When regulations are changed, these baseline studies would continue to provide relevant information.

In a monitoring strategy document for Washington, Schuett-Hames *et al.* (1996) noted that monitoring of aquatic resource trends was important because protection and restoration of aquatic habitat and species are the fundamental management objectives. Too often we hear of the progress by point source programs to improve water quality without having data to demonstrate positive trends for nonpoint source pollution control efforts. The plans for trend monitoring in Washington, monitoring in managed watersheds in Colorado, stream habitat condition inventories in Oregon, and the ongoing Caspar Creek Study in California, represent the first efforts to develop that trend data.

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