Chapter 5: Monitoring and Tracking Techniques

This chapter discusses monitoring the implementation and effectiveness of forestry management measures. For the most part, such monitoring is done either for research purposes or to assess compliance with regulatory requirements or recommendations. Therefore, it is usually the domain of universities or government agencies and this chapter is directed primarily at state agencies responsible for compliance with forestry regulations, nonpoint source pollution control regulations, or voluntary forest practice programs. Owners and managers of large forestland tracts are encouraged to work with state officials to develop a means of monitoring the implementation of BMPs on their lands to assess whether they are installed and maintained adequately so that they will protect water quality effectively, regardless of whether the state's program mandates forest practice implementation or encourages voluntary implementation.

Overview

Designing and legally implementing a state program of management practices for forest harvests and forest road construction cannot protect water quality unless the BMPs are implemented by those who actually harvest the timber or manage the land to be harvested. Monitoring the implementation of BMPs is a crucial element of any BMP program. Monitoring provides feedback on whether management practices are implemented per the specifications required or recommended by state and federal governments, on how the forestry practice program is received by harvesters and landowners, and on forestry practice design and use standards and specifications so they can be refined to be more useful and more effective.

Many states have implemented programs to monitor the implementation of forestry practices at harvest sites in conjunction with the passage of forest practice legislation or after a state has established a set of forestry practice recommendations. The end of this chapter provides information about some of these programs. Fewer states monitor the effectiveness of management practices at protecting water quality as part of their BMP implementation monitoring programs. However, even a limited amount of effectiveness monitoring, such as under controlled conditions during experimental harvests, is important to ensure that BMP design specifications and standards are adequate to protect water quality and soils. Once it is determined that BMPs that are installed according to standards and specifications are actually effective, it can be acceptable to monitor only the implementation of BMPs to ensure that they are properly installed, the assumption being that if they are installed adequately, then they effectively protect water quality and forest resources. Such an approach is often necessary because of the difficulty and cost in measuring water quality directly and confounding factors such as upstream pollution sources. Without the initial information that adequately installed BMPs are effective, though, little can be said about the degree of water quality and forest resource protection attained by adequately installing BMPs.

Monitoring Program Fundamentals

The most fundamental step in the development of a monitoring plan is to define the goals and objectives, or purpose, of the monitoring program. In general, monitoring goals are broad statements such as “to measure changes in fish spawning habitat” or “to measure nutrient loading to streams adjacent to harvest sites.” Monitoring programs can be grouped according to the following general statements of purpose or expected outcomes:

- Describe status and trend
- Describe and rank existing and emerging problems
- Design management and regulatory programs
- Evaluate program effectiveness
- Respond to emergencies
- Evaluate the implementation of best management practices
- Evaluate the effectiveness of best management practices
- Validate a proposed water quality model
- Perform research

Unlike monitoring goals, monitoring objectives are more specific statements that can be used to add detail, including geographic scale, measurement variables, sampling methods, and sample size, to the monitoring design. Detailed monitoring program objectives enable the designer of the program to define precisely what data will be gathered in order to meet the management goals. Vague or inaccurate statements of objectives lead to program designs that provide too little or too much data, thereby either failing to meet management needs or costing too much.

Numerous guidance documents have been developed, or are in development, to assist resource managers in developing and implementing monitoring programs that address all aspects of monitoring design. Appendix A in *Monitoring Guidance for Determining the Effectiveness of Nonpoint Source Controls* (USEPA, 1997) presents a review of more than 40 monitoring guidances for both point and nonpoint source pollution. These guidances discuss virtually every aspect of nonpoint source pollution monitoring, including monitoring program design and objectives, sample types and sampling methods, chemical and physical water quality variables, biological monitoring, data analysis and management, and quality assurance and quality control.

Once the monitoring goals and objectives have been established, existing data and constraints are considered. A thorough review of literature pertaining to water quality studies previously conducted in the geographic region of interest can help determine whether existing data provide sufficient information to address the monitoring goals and what data gaps exist.

Identification of project constraints address financial, staffing, and temporal elements. Clear and detailed information is obtained on the time frame within which management decisions need to be made, the amounts and types of data that is to be collected, the level of effort needed to collect the necessary data, and equipment and personnel needed to conduct the monitoring. From this information it can be determined whether available personnel and budget are sufficient to implement or expand the monitoring program.

As with monitoring program design, the level of monitoring that will be conducted is largely determined when goals and objectives are set for a monitoring program, although there is some flexibility for achieving most monitoring objectives.

The overall scale of a monitoring program has two components—a temporal scale and a geographic scale. The temporal scale is the amount of time required to accomplish the program objectives. It can vary from an afternoon to many years. The geographic scale can also vary from quite small, such as plots along a single stream reach, to very large, such as an entire river basin. The temporal and geographic scales, like a program's design and monitoring level, are primarily determined by the program's objectives.

If the main objective is to determine the current biological condition of a stream, sampling at a few stations in a stream reach over 1 or 2 days might suffice. Similarly, if the monitoring objective is to determine the presence or absence of a nonpoint source effect, a synoptic survey might be conducted in a few select locations. If the objective is to determine the effectiveness of a watershed forest management program for improving water quality conditions in streams, however, monitoring subwatersheds for 5 years or longer might be necessary. If the objective is to calibrate or verify a model, very intensive sampling might be necessary.

Depending on the objectives of the monitoring program, it might be necessary to monitor only the water body with the water quality problem or it might be necessary to include areas that have contributed to the problem in the past, areas containing suspected sources of the problem, or a combination of these areas. A monitoring program conducted on a watershed scale will include a decision about the watershed's size. The effective size of a watershed is influenced by drainage patterns, stream order, stream permanence, climate, number of landowners in the area, homogeneity of land uses, watershed geology, and geomorphology. Each factor is important because each has an influence on stream characteristics, although no direct relationship exists.

There is no formula for determining appropriate geographic and temporal scales for any particular monitoring program. Rather, once the objectives of the monitoring program have been determined, a combined analysis of them and any background information on the water quality problem(s) being addressed will make it clear what overall monitoring scale is necessary to reach the objectives.

Other factors that can be considered to determine appropriate temporal and geographic scales include the type of water resource being monitored and the complexity of the nonpoint source problem. Some of the constraints mentioned earlier, such as the availability of resources (staff and money) and the time frame within which managers need monitoring information, will also contribute to determination of the scale of the monitoring program.

For additional details regarding nonpoint source monitoring techniques, including chemical and biological monitoring, refer to *Monitoring Guidance for Determining the Effectiveness of Nonpoint Source Controls* (USEPA, 1997). This technical document focuses on monitoring to evaluate the effectiveness of management practices, but also includes approximately 300 references and summaries of more than 40 other monitoring guides. In addition, Chapter 8 of EPA's management measures guidance for section 6217 contains a detailed discussion of monitoring (USEPA, 1993).

Monitoring BMP Implementation

The implementation of management measures and BMPs should be tracked to determine the extent to which the measures are implemented on harvest sites or throughout a watershed. Data on BMP implementation and trends in BMP implementation can be used to address the following goals:

- Determine the extent to which BMPs are implemented in accordance with relevant standards and specifications.
- Determine whether there has been a change from previous years in the extent to which BMPs are being implemented.
- Establish a baseline from which decisions can be made regarding the need for additional incentives for implementation of BMPs.
- Determine the extent to which BMPs are properly maintained and operated.
- Measure the success of voluntary BMP implementation programs.
- Determine how and why BMP use varies from one geographic area to another.
- Support workload and costing analyses for landowner assistance or regulatory programs.

Methods to assess the implementation of management measures are a key focus of the technical assistance to be provided by EPA and NOAA under CZARA section 6217.

Implementation assessments can be done on several scales. Site-specific assessments can be used to assess individual management practices or management measures, and watershed assessments can be used to look at the cumulative effects of implementing multiple management measures. With regard to "site-specific" assessments, it is important to assess individual management practices at the appropriate scale for the practice of interest. For example, to assess the implementation of management measures or management practices for forest roads at harvest sites, only the roads at timber harvesting sites would need to be inspected. In this example, the scale would be a timber harvest area and the sites would be active and inactive roads at the harvest areas. To assess implementation of management measures and practices at streamside management areas, the proper scale might be a harvest area larger than 10 acres and the sites could be areas encompassed by buffer areas for 200-meter stretches of stream. For site preparation and forest regeneration, the scale and site might be an entire harvest site. Site-specific measurements can then be used to extrapolate to a watershed or statewide assessment.

Sampling design, approaches to conducting the evaluation, data analysis techniques, and ways to present evaluation results are described in EPA's *Techniques for Tracking, Evaluating, and Reporting the Implementation of Nonpoint Source Control Measures—Forestry* (USEPA, 1997a), from which much of the text for this chapter has been borrowed. Chapter 8 of EPA's management measures guidance for section 6217 contains a detailed discussion of techniques and procedures to assess implementation, operation, and maintenance of management measures (USEPA, 1993).

Monitoring BMP Effectiveness

By tracking management measures and water quality simultaneously, analysts gain the information necessary to evaluate the performance of the management measures implemented. Management measure tracking provides information on whether pollution controls are being implemented, operated, and maintained adequately. Only with such information is it possible to draw conclusions from water quality monitoring data about the effectiveness of management practices.

A major challenge in attempting to relate implementation of management measures to water quality changes is determining the appropriate land management attributes to track. For example, simply counting the number of management measures implemented in a watershed has little chance of being useful in statistical analyses to relate water quality to land treatment since the count only remotely relates (i.e., a mechanism is lacking) to the measured water quality parameter (e.g., cobble embeddedness). Land treatment monitoring that relates directly to the pollutants or effects monitored at the water quality station is most useful. For example, the spacing of water bars relative to slope might be a more useful parameter to track than the number of miles of road constructed. Since the effect of management measures on water quality might not be immediate or implementation might not be sustained, information on other relevant watershed activities (e.g., urbanization, wildfire frequency and extent) is essential for the final analysis.

Management practice effectiveness has not been well documented on a watershed scale, particularly for watersheds with mixed land uses. Studies of management practice effectiveness have been done at the plot and field scales where specific treatments are used and compared to a control situation. Extrapolations from these data and studies using nonpoint source pollution models constitute most of the information available on a watershed scale. Actual data collection and management practice effectiveness determination on a watershed scale is more complex and, because of natural variability, it requires long periods of monitoring before management practice implementation so that a statistical minimum detectable change level can be established. The minimum detectable change is the minimum measurable change in a water quality parameter over time that is statistically significant, and it is a function of statistical tests, the number of samples taken per year, the number of years of monitoring, and the variates and covariates used in the analyses. Dissmeyer (1994) provides detailed information on monitoring forestry BMPs to evaluate their effectiveness in meeting water quality goals. An approach for watershed monitoring of management practice effectiveness, and the problems associated with the approach and with such studies in general, is discussed in Park and others (1994).

Appropriately collected water quality information can be evaluated with trend analysis to determine whether pollutant loads have been reduced or whether water quality has improved. Valid statistical associations drawn between implementation and water quality data can be used to indicate the following:

- Whether management measures have been successful in improving water quality in a watershed or recharge area.
- The need for additional management measures to meet water quality objectives in the watershed or recharge area.

Greater detail regarding methods to evaluate the effectiveness of land treatment efforts is provided in EPA's nonpoint source monitoring guidance (USEPA, 1997) and management measures guidance for section 6217 (USEPA, 1993).

Importance of BMP Monitoring

Researchers with the U.S. Forest Service reviewed state BMP implementation and monitoring programs and the results from those programs in 1994. At the time, twenty-one states were assessing BMP effectiveness. They found that the states had generally concluded that carefully developed and applied BMPs can prevent serious deterioration of water quality, and that most water quality problems were associated with poor BMP implementation. Water quality monitoring was determined to be essential to understanding the relationship between land disturbance and water quality, as it leads to improved understanding of the interaction of soils and topography with BMP implementation. BMP guidelines can be reassessed continually to make them more cost effective, and the more they can be specified, used, monitored, and fine tuned for specific circumstances, the more cost-effectively they can be used to protect water quality.

Quality Assurance and Quality Control

Quality assurance (QA) and quality control (QC) are commonly thought of as procedures used in the laboratory to ensure that all analytical measurements made are accurate. But QA and QC extend beyond the laboratory and are essential components of all phases and all activities within each phase of a nonpoint source monitoring project.

Definitions of Quality Assurance and Quality Control

Quality assurance is an integrated management system designed to ensure that a product or service meets defined standards of quality with a stated level of confidence. Quality assurance activities involve planning quality control, quality assessment, reporting, and quality improvement.

*Quality contro*l is the overall system of technical activities designed to measure quality and limit error in a product or service. A quality control program manages quality so that data meet the needs of the user as expressed in a quality assurance project plan.

Quality control procedures include the collection and analysis of blank, duplicate, and spiked samples and standard reference materials to ensure the integrity of analyses, as well as regular inspection of equipment to ensure it is operating properly. Quality assurance activities are more managerial in nature and include assignment of roles and responsibilities to project staff, staff training, development of data quality objectives, data validation, and laboratory audits. Such procedures and activities are planned and executed by diverse organizations through carefully designed quality management programs that reflect the importance of the work and the degree of confidence needed in the quality of the results.

Importance of Quality Assurance and Quality Control Programs

Although the value of a QA/QC program might seem questionable while a project is under way, its value will be quite clear after a project is completed. If the objectives of the project were used to design an appropriate data collection and analysis plan, all QA/QC procedures were followed for all project activities, and accurate and complete records were kept throughout the project, the data and information collected from the project should be adequate to support a choice from among alternative courses of action. In addition, the course of action chosen should be defensible based on the data and information collected. Development and implementation of a QA/QC program can require up to 10 to 20 percent of project resources (Cross-Smiecinski and Stetzenback, 1994), but this cost can be recaptured in lower overall costs due to the project's being well planned and executed. Likely problems are anticipated and accounted for before they arise, eliminating the need to spend countless hours and dollars resampling, reanalyzing data, or mentally reconstructing portions of the project to determine where an error was introduced. QA/QC procedures and activities are cost-effective measures used to determine how to allocate project energies and resources toward improving the quality of research and the usefulness of project results.

EPA Quality Policy

EPA has established a QA/QC program to ensure that data used in research and monitoring projects are of known and documented quality to satisfy project objectives. The use of different methodologies, lack of data comparability, unknown data quality, and poor coordination of sampling and analysis efforts can delay the progress of a project or render the data and information collected from it insufficient for decision making. QA/QC practices are best used as an integral part of the development, design, and implementation of a nonpoint source monitoring project to minimize or eliminate these problems.

Additional information on QA/QC can be found in Chapter 5 of EPA's nonpoint source monitoring guide (USEPA, 1997) and in EPA documents on QA/QC.

Review of State Management Practice Monitoring Programs

Objectives of the Audits

In general, state audits of harvest sites or other types of forestry operations have as their primary objectives to assess compliance with BMP implementation guidelines and/or the effectiveness of BMPs at preventing soil erosion and protecting water quality. Additionally, because the process of collecting BMP implementation and effectiveness information lends itself well to the collection of related information that can be quite useful to a state forestry department, states also collect information that will help them to

- Identify problem areas where additional landowner training and education is needed to improve BMP implementation.
- Determine which BMP implementation standards and specifications need revision.
- Identify necessary improvements in the BMP monitoring program.

Information on landowner training is easily gathered during the audits if the landowner on whose property a harvest was done is present during the audit or contacted as part of the audit. Landowners can be contacted before the audit in most instances to obtain permission to enter their property, and they can be asked to be present either during the audit, when they can perhaps offer valuable information about the harvest, or after an audit during a discussion of the results.

Analysis of BMP implementation standards and specifications can be done effectively during an audit, or during an analysis of audit results after an annual audit has been completed, by comparing the implementation and effectiveness information gathered during the audit with state implementation specifications. For example, specifications may call for a recommended maximum distance between culverts on forest roads of a given slope. During the audits it might be noticed that, even where these specifications have been adhered to, erosion is unacceptable. It may then be recommended to lower the maximum distance, or it might be noticed that excessive erosion is related to a particular soil type, and a shorter distance might be recommended where this soil type occurs.

Audits can provide valuable information about the monitoring program, too. It might be discovered during the course of audits that instances of particular types of effects to soils or water resources are increasing over the years. Or it might be recognized that certain forestry operations (e.g., prescribed burning or site preparation) might not be accounted for in the audits adequately enough to draw conclusions about effects to water resources. Information collected during the audits can be used to adjust the monitoring program to actual information needs.

Audits conducted by some states serve specific objectives beyond assessments of BMP implementation and effectiveness. A good example is South Carolina, which has designed the data collection aspect of its BMP implementation survey to permit the state to determine the effect of a number of variables on compliance with BMP standards. The variables investigated include

- Physiographic region in which the harvest occurred
- Occurrence of a stream on the harvest site
- Percent slope at the harvest site
- Type of terrain at the harvest site
- Category to which the landowner belonged
- Use of cost share assistance for the harvest
- Landowner’s familiarity with state BMPs
- Use of a site preparation contract
- Written requirement for the use of BMPs
- Involvement of a forester in the prescription and supervision of site preparation
- Size of the area being site-prepared for reforestation

Criteria Used to Choose the Audit Sites

States use a number of criteria to select sites for inclusion in BMP audits. Generally, the criteria exclude from the audits those sites where BMPs of interest would not likely have been used, where the types of effects of interest (e.g., impacts to water quality) would be difficult to detect or nonexistent, and sites where detecting whether BMPs had been implemented would be difficult due to changes in site characteristics since their implementation. Other criteria ensure that sites from different topographic or vegetative community areas or administrative jurisdictions (e.g., counties or state forest service regions) are included in the audits.

The use of criteria result in a biased sample of audit sites, and thus the conclusions from the audits cannot be used to draw conclusions about all harvest sites in a state. But complete random sampling of harvest sites would limit the usefulness of the results more than biasing the selection of sites by the use of criteria. Not limiting the sites chosen for the audits would result in the inclusion of sites where harvests had occurred many years previously and physical evidence of BMP implementation would be undetectable, sites in areas where BMPs of interest (such as those related to SMAs) would not have been used, and would possibly result in not including portions of the state of interest to the state forestry agency. Therefore, it is important to use criteria to ensure that audit sites provide the information of interest.

The following are some of the criteria used in state audits.

Geographic Distribution

Generally, an entire state is included in an audit by choosing a minimum number of sites per county. A minimum of one site per county is a common criterion, though if timber harvesting is limited to certain areas, a state might include only those counties in which timber was harvested during the time period of interest (see second criterion). The geographical distribution of audit sites might be related to the quantity of timber harvested in a county by ensuring that the latter is proportional to the number of sites chosen for the county. Depending on the purpose of the audit, some other potential site selection criteria are

- Sites within a specific watershed.
- The geographic distribution of audit sites reflects the distribution of timber harvest ownership group.
- All physiographic regions of the state are represented.

Time Since Harvest

The timber harvest or other management activity of interest (e.g., site preparation, road construction) is to have occurred within a specific period of time, typically 1 to 2 years, prior to the audit. There are two good reasons to conduct audits as soon as possible after a harvest. First, the longer the delay between a harvest and an audit, the more difficult it will be to determine the adequacy of BMP implementation. With the passage of time natural vegetation growth can hide evidence of the adequacy of soil conservation measures, storms can obliterate evidence of the adequacy of erosion control methods, and the like. Second, most erosion and sedimentation caused by a harvest activity occurs during and shortly after the harvest, and the longer the time between a harvest and an audit of the harvest, the less likely it is that the audit results will be able to help correct BMP implementation problems and, therefore, minimize water quality impacts. Ideally, BMP implementation and effectiveness audits should occur during harvest-related activity.

Minimum Size

Audit sites are generally no less than 5 to 10 acres, which ensures that BMP use would have been called for. A minimum volume of harvested timber is another way of ensuring the same.

Proximity to Watercourse

Most states insist that harvest sites have a stream (perennial or intermittent), lake, wetland, or pond of a certain size on or near them. The criterion might be that the watercourse is on the audit site, especially if a primary goal of the audit is to assess implementation of SMA rules or guidelines, or within 200 to 500 feet of the audit site if water quality effects of harvest operations are of particular concern. States that are interested in overall BMP implementation might not care that audit sites be associated with surface waters.

Representation of Ownership

Inclusion of all ownership groups (private nonindustrial, industrial, federal, state, and local) can be a criterion for choosing sites, though generally audit sites are not specifically chosen to represent the ownership groups. If all ownership groups are to be included, states might use this criterion only if a minimum number of sites per ownership group is not reached using the other criteria. When this happens, sites from the overrepresented ownership group or groups are randomly deselected and sites from the underrepresented group are randomly selected from those of the desired ownership group.

Randomness

Although, as stated above, simple randomness is not an overriding concern in the design of BMP audits, many states do ensure that once the criteria are met, sites are then selected randomly, resulting in a stratified random sampling design.

Audit Focus: BMP Implementation and BMP Effectiveness

Surveys are geared toward investigating either BMP implementation or BMP effectiveness or both of these. The nature of the forestry activity at any given site that is investigated determines which BMPs are appropriate for implementation at the site or required to be used, depending on whether BMP use is mandatory or voluntary. Sites are generally rated based on the BMPs that should have been used at the site. If a timber harvest plan was prepared prior to the harvest, or a road construction plan prepared prior to construction of a road and BMPs were included in the plan(s), then the survey might investigate whether the BMPs included in the plan were actually implemented.

Number of Sites Investigated

The number of sites investigated varies widely and depends on survey design, amount of silviculture activity in the state, and availability of resources (staff and money). If the results of the survey are to be analyzed statistically, then the number of sites investigated must be sufficient for this purpose. See EPA's *Techniques for Tracking, Evaluating, and Reporting the Implementation of Nonpoint Source Control Measures—Forestry* (USEPA, 1997a) for guidance on selecting a sufficient number of sites for statistical analysis purposes. A difficulty for many states is ensuring that the number of harvest sites inspected is adequate to draw meaningful conclusions about overall BMP implementation. The number of sites harvested within the audit timeframe (e.g., 2 years if the audit includes sites harvested within the 2 years prior to the audit) is often not known. Many states do not require preharvest notification, or that a landowner inform the state department of forestry that a harvest will occur and where it will occur. Without this information, a state cannot know with certainty what percentage of harvest sites are included in an audit and finding sites to audit can be a difficult, costly, time-consuming task. Even if a state has a policy of voluntary implementation of its forestry BMPs or guidelines, simply requiring that landowners report to the state department of forestry when and where a harvest will occur and the acreage to be harvested, the state's ability to audit BMP implementation in a timely manner, track BMP implementation trends, assist landowners with proper BMP implementation, and maintain accurate statistics about forestry activity in the state can be greatly improved.

Number of BMPs Evaluated

The number of BMPs investigated at each site varies depending on the objectives of the survey and the number and types of BMPs recommended or required by the state. Surveys that target specific types of operations or locations, such as road construction or SMAs, generally involve investigations of fewer BMPs than surveys to assess the use of BMPs for all aspects of forest harvesting, from temporary road construction to site preparation for reforestation.

Composition of the Investigation Teams

An investigation "team" can range from one person to a team of 5 to 7 people with different specialties. Again, the composition of the survey team depends on the objectives of the survey. If BMP implementation is the only thing being investigated, then a state forester alone might be capable of conducting the survey. If, on the other hand, soil characteristics, erosion hazard, improvements in road construction techniques, water quality effects, or other more complex issues are also being investigated, then a team of individuals that represent the appropriate disciplines is generally used.

When one person conducts the surveys, generally the person is a state forester who is familiar with BMP standards for both implementation and effectiveness. When teams are used for the surveys, the state forester is accompanied by one or more specialists that represent fields such as watershed science, soil science, wildlife biology, hydrology, fisheries, and road engineering. Separate organizations might also be represented, such as environmental or conservation organizations and the logging industry. Where possible, the survey team is accompanied by the landowner on whose property the survey is being conducted, the logger who conducted the harvest, and the state forester who prepared the harvest plan, if applicable. Examples of who might be included on an audit "team" are

- A county or state forester
- A watershed specialist
- A forestry industry representative
- A member of the environmental community
- A nonindustrial private landowner
- A member of a local or regional planning and development board
- A wildlife biologist
- A hydrologist
- A soil conservationist or soil scientist
- A fisheries biology

- A road engineer
- A logging professional

BMP Implementation and Effectiveness Rating Systems

The implementation of individual BMPs is rated in one of two ways. A scale of implementation, usually from 0 to 5 or 0 to 3, is used to rate not only whether a BMP was implemented but also the quality of implementation. Alternatively, BMPs are rated simply as having been implemented, not implemented, or not applicable to the particular site.

Generally, all BMPs applicable to a site are rated individually and the site then receives an overall BMP implementation rating. The latter rating might be made using one of the two rating systems mentioned above or using a 3-tiered rating system of excellent, adequate, or inadequate. The overall site rating is usually derived as an average of the individual BMP ratings at the site. Low ratings for overall BMP implementation—for example zero to two on a 0-to-5 scale, zero on a 0-to-3 scale, and inadequate on a 3-tiered rating system—are indications that follow-up with the landowner or harvester is necessary or that further education and training might be helpful.

Even when only BMP implementation is being assessed, BMP effectiveness is often rated on a qualitative basis as an onsite assessment of whether, in the case of a low score or inadequate BMP implementation, there was a resultant risk to water quality. Risks to water quality are generally rated as simply being present or not. If it is apparent that water quality was affected by inadequate BMP implementation, this is also noted.

When more than one team is responsible for the assessments and where teams are composed of many people, assessment training or a mock assessment is performed prior to the actual assessments to establish a degree of consistency in the ratings among members and teams. Assessments of adequacy of BMP implementation and risk to water quality can involve many subjective judgements, and going through a mock assessment prior to the actual assessments gives all team members a chance to discuss what constitutes adequate or proper implementation for the different BMPs. In addition, in many states, after a site assessment and while the assessment team is still on the site the team gathers to discuss the ratings of the individual team members and to arrive at an overall site rating. If any discrepancies or differences of opinion cannot be settled through discussion alone, the individual BMPs are revisited.

Audit Results

Successful implementation of BMPs by landowners and harvesters, as indicated by audits with high compliance rates, depends on many factors, such as whether a state's BMP program is mandatory or voluntary, how long a state has had a BMP program, how long a state has been monitoring BMP implementation, and the effectiveness of a state's education and training outreach program for BMP implementation.

Results of many state audits for BMP implementation and effectiveness indicate that BMPs are being implemented and, where implemented, they are effective in protecting soil from erosion and water quality. Results are generally reported in one of two ways: an overall compliance rate, in which all ratings for compliance with individual BMPs or groups of BMPs are averaged into a single number, and compliance rates for individual

BMPs or groups of BMPs. A group of BMPs might be all those required for SMAs, for instance.

An overall compliance rate can be misleading because it is essentially an average of averages. That is, an overall compliance rate is generally obtained by averaging the compliance ratings for separate groups of BMPs, and then those averages are averaged. Instances where such a rating would be misleading include where most groups of BMPs are rated to have high compliance while one important group of BMPs, say those for SMAs or stream crossings, has a much lower compliance rate. The compliance information for the latter group is lost in the overall compliance rating. Of course, a low overall compliance rating, caused by low compliance ratings for many groups of BMPs, can hide a high compliance rating for another group of BMPs as well. Similarly, a single or a few high or low ratings for individual BMPs within a group of BMPs can be hidden by averaging together the compliance ratings for a whole group of BMPs. Generally, states gain far more information useful to them and to the public for improving and reporting BMP compliance if ratings for individual BMPs are kept separate. Trend analyses for implementation of individual BMPs are also much more meaningful than reports of changes in overall compliance for BMPs from one audit to the next. Of course, it is very important to keep data relevant to the effectiveness of individual BMPs, such as that on the slopes of roads where failure occurs or the amount of cover retained in SMAs where sediment reaches streams, separate for each BMP so that improvements can be made to state BMP specifications.

EPA Recommendations for Forestry Practice Audits

Implement a preharvest notification system to assist in selecting an adequate and unbiased sampling population of harvest sites, to reduce the cost of site selection, and to help determine, prior to a site visit, that selected sites meet many of the selection criteria such as time since harvest and size of harvest.

If feasible, conduct audits soon after harvests are completed so that improvements can be made to BMPs found to be inadequately implemented and the water quality impacts of those BMPs can be minimized.

Ensure that harvest sites are chosen randomly. Stratification based on desired characteristics of sites is perfectly acceptable, but if this is done then sampling within the strata must be random to ensure the validity of results.

If the geographic extent of an audit includes a critical watershed, create a separate statistically valid sample population for the watershed and do not group information from harvests within the watershed with information from other harvests. It is important to maintain separate information for watersheds that have been designated “critical” and to sample them separately if the information obtained is to be related to and useful for programs instituted to protect the watersheds.

Have a clearly defined process for or means of determining whether a BMP implementation is acceptable or not. Audits may be conducted with teams of experts or by individuals working at different harvest sites. The subjectivity of BMP ratings can be reduced and their objectivity increased by clearly defining what standards and quality of implementation constitute each rating level in the rating scale being used. Auditors well trained to recognize these standards and quality criteria will provide the most objective, consistent, meaningful, and comparable ratings.

Ensure that BMP implementation according to state standards reflects protection of water quality by collecting data that is sufficient to determine the effectiveness of BMPs under specific circumstances, such as different soil types, topographies, and rainfall patterns. Modify state standards if the data collected indicate that existing standards are insufficient under certain circumstances.

If forest practice implementation or effectiveness ratings are to be grouped for reporting purposes, maintain separate groupings for functionally different BMPs. For instance, create separate group ratings for road erosion BMPs, stream crossing BMPs, SMA BMPs, etc., so that an average compliance rating will not hide important information about which BMPs are not being implemented adequately.

Volunteer Water Monitoring

The information presented below is available from the USEPA Web site (http://www.epa.gov/owow/monitoring/volunteer/startmon.html) and as a published brochure (United States Environmental Protection Agency; Office of Water (4503F), Washington, DC 20460; EPA 841-B-98-002; July 1998).

Volunteer water monitoring is monitoring done by local citizens rather than agency personnel. In every state, volunteers monitor the condition of streams, rivers, lakes, reservoirs, estuaries, coastal waters, wetlands, and wells. Volunteers who monitor are people who want to help protect a stream, lake, bay or wetland near where they live, work, or play. Their efforts are of particular value in providing quality data and building stewardship of local waters.

Volunteers make visual observations of habitat, land uses, best management practices used to protect soil and water resources; and the impacts of storms; measure the physical and chemical characteristics of waters; and assess the abundance and diversity of living creatures–aquatic insects, plants, fish, birds, and other wildlife. Volunteers also clean up garbage-strewn waters, count and catalog beach debris, and become involved in restoring degraded habitats. The number, variety, and complexity of these projects are continually on the rise.

Volunteer monitoring programs are organized and supported in many different ways. Projects may be entirely independent or may be associated with state, interstate, local, or federal agencies; with environmental organizations; or with schools and universities. Financial support may come from government grants, partnerships with business, endowments, independent fundraising efforts, corporate donations, membership dues, or a combination of these sources.

Many volunteer groups collect data that supplements the information collected by state and local resource management or planning agencies. These agencies might use the data to

- Evaluate the success of best management practices designed to mitigate problems.
- Screen water for potential problems, for further study or for restoration efforts.
- Establish baseline conditions or trends for waters that would otherwise go unmonitored.

In general, a volunteer monitoring program should work cooperatively with state and local agencies in developing and coordinating its technical components. To ensure that its data are used, the monitoring program also develops a strong quality assurance project plan that governs how volunteers are trained, how samples are collected and analyzed, and how information is stored and disseminated.

By educating volunteers and the community about the value of local waters, the kinds of pollution threatening them, and how individual and collective actions can help solve specific problems, volunteer monitoring programs can

- Make the connection between watershed health and our individual and collective behaviors (cumulative impacts).
- Build bridges among various agencies, businesses, and organizations.
- Create a constituency for local waters that promotes personal and community stewardship and cooperation.

Information on volunteer monitoring efforts locally and nationwide can be found through USEPA. The *National Directory of Volunteer Environmental Monitoring Programs*, published by USEPA, provides information on existing groups around the country and the kinds of monitoring taking place. In addition, USEPA's *Adopt Your Watershed* site on the World Wide Web (http://www.epa.gov/adopt/) provides information on active volunteer groups on a watershed basis.

Local or state environmental protection, natural resource, parks, or fish and game agencies might also be good sources of information. Even if the agency does not sponsor a volunteer program, it might be aware of other programs or groups that are active. Other potential sponsors or sources of information include

- Local community-based groups such as civic or watershed associations, garden clubs, universities, and activist organizations
- Chapters of national environmental organizations
- Regional offices of federal agencies such as USEPA, the US Department of Agriculture's Extension Service, the U.S. Park Service, and the U.S. Fish and Wildlife Service

Volunteer Monitoring Resources

USEPA supports volunteer monitoring by sponsoring national conferences, publishing methods manuals, producing a nationwide directory of volunteer programs, and funding a national newsletter, *The Volunteer Monitor*. Volunteer coordinators in the 10 EPA Regional offices provide some technical assistance for local programs and help coordinate regionwide conferences. The Regions are also responsible for grants to the states that can be used, in part, to support volunteer monitoring programs that help assess nonpoint sources of pollution or that serve to educate the public about nonpoint source issues.

Some USEPA resources on the World Wide Web

Volunteer Monitoring Homepage	http://www.epa.gov/owow/monitoring/volunteer/
Monitoring Water Quality Homepage	http://www.epa.gov/owow/monitoring/
Surf Your Watershed	http://www.epa.gov/surf/
Adopt Your Watershed	http://www.epa.gov/adopt/
Index of Watershed Indicators	http://www.epa.gov/iwi/

Documents on volunteer monitoring published by USEPA are listed below. Copies can be obtained by contacting the Volunteer Monitoring Coordinator, USEPA (4503F), 401 M Street SW, Washington, DC 20460.

National Directory of Citizen Volunteer Environmental Monitoring Programs, Fifth Edition. EPA 841-B-98-009, November 1998.

Proceedings of the Fifth National Citizen's Volunteer Water Monitoring Conference. EPA 841-R-97-007, October 1997.

Proceedings of the Fourth National Citizen's Volunteer Water Monitoring Conference. EPA 841/R-94-003, February 1995.

Proceedings of the Third National Citizen's Volunteer Water Monitoring Conference. EPA 841/R-92-004, September 1992.

Volunteer Estuary Monitoring: A Methods Manual. EPA 842-B-93-004, December 1993.

Volunteer Lake Monitoring: A Methods Manual. EPA 440/4-91-002, December 1991.

Volunteer Monitor's Guide to Quality Assurance Project Plans. EPA 841-B-96-003, September 1996.

Volunteer Stream Monitoring: A Methods Manual. EPA 841-B-97-003, November 1997.

Volunteer Water Monitoring: A Guide for State Managers. EPA 440/4-90-010, August 1990.

The Volunteer Monitor, published semiannually, is the national newsletter of volunteer water monitoring. The newsletter facilitates the exchange of ideas, monitoring methods, and practical advice among volunteer monitoring groups across the country. Subscriptions are free. Address all correspondence to Eleanor Ely, Editor, 1318 Masonic Avenue, San Francisco, CA 94117; phone 415/255-8049; fax 415/255-0199.

Best Management Practices Evaluation Program: U.S. Forest Service, Pacific Southwest Region

The USDA Forest Service Pacific Southwest Region has published *Investigating Water Quality in the Pacific Southwest Region: Best Management Practices Evaluation Program (BMPEP) User's Guide* (USDA-FS, Pacific Southwest Region, 2002). The guide continues an effort begun in 1992 to monitor and evaluate BMP implementation and effectiveness (USDA-FS, Pacific Southwest Region, 1992). The Best Management Practices Evaluation Program, or BMPEP, was developed to facilitate evaluation of BMPs through the generation and analysis of data to assess the efficacy of the Region's water quality program, and identify program shortcomings and initiate corrective actions (USDA-FS, Pacific Southwest Region, 2002).

There are three types of BMP evaluations, Administrative, In-Channel, and On-Site. Individuals or teams of reviewers conduct the evaluations using Forest Service forms. *Administrative Evaluations* involve assessing all BMPs for a project, including procedural BMPs (such as the Timber Sale Planning Process). *In-Channel Evaluations* assess the effectiveness of a set of BMPs applied to a project area for protecting beneficial uses of water. All BMPs prescribed for a project for water quality protection are evaluated by establishing study sites to assess effects on beneficial uses over time. *On-Site Evaluations* involve assessing both the implementation and effectiveness of specific practices (individual or groups of similar BMPs). The BMPs are assessed at the site of implementation and evaluated relative to attainment of each BMP's stated objectives.

For in-channel evaluations, sites are selected on the basis of their being representative of management activities common to the forest being evaluated (e.g., timber, mineral extraction, developed recreation, range use) and located in watersheds that are representative of the forests' dominant landforms and geologic types. Streams selected for project evaluation have a suitable control (or comparison stream) nearby or have established desired future condition criteria that can serve as the basis of comparison. A monitoring plan is also developed for each in-channel evaluation. The monitoring plan describes the location, beneficial uses to be protected, evaluation objectives, data collection parameters and methods, timing/frequency and duration of collection, analytical techniques, and the decision criteria to be used to determine whether the beneficial uses were protected. A follow-up investigation is conducted when data from an in-channel evaluation indicates that beneficial use protection objectives were not met and to identify causes of nonpoint source degradation.

On-site evaluations focus on the implementation and effectiveness of individual BMPs applied on project sites. These evaluations are essentially used to answer the implementation question "Did we do what we said we were going to do to protect water quality?" and the effectiveness question "How well did we protect water quality?" There are 29 different evaluation procedures, each designed to assess a specific BMP or set of closely related BMPs. For example, one procedure evaluates SMAs; another evaluates grazing; and another evaluates recreational facilities. Each evaluation procedure has its own form where ratings and comments are recorded, and each form has an electronic counterpart in database software. The evaluations are completed by those persons responsible for the execution of the practices being evaluated. For example, a Range Conservationist or Resource Officer would conduct the on-site evaluation of grazing, a Sale Administrator or Planner would conduct the evaluation of SMAs, and an Engineer would conduct the evaluation of road drainage control.

Sites to be evaluated are either selected randomly or selected. Randomly identified sites allow for drawing statistical conclusions on the implementation and effectiveness of BMPs. Random sites are picked from a pool of projects that meet specified criteria. Selected sites are identified in various ways, such as from a monitoring plan prescribed in an EA, EIS or LMP; as part of a routine site visit; as part of a follow-up evaluation to an in-channel evaluation to discover sources of problems; or selected for a particular reason specific to local needs. Note that for statistical analysis, only randomly identified sites are used to develop statistical inferences. Selected sites are clearly identified and kept separate from the random sites during data storage and analysis.

When problems in implementation are discovered during an audit, the probable cause and recommended corrective actions to prevent recurrence are noted. Reviewer comments are extremely valuable in this regard. Effectiveness evaluations are made using specific indicators of the success of the BMPs observed or measured on-site. When effectiveness problems are noted, observers comment on the extent, duration, and magnitude of effects on beneficial uses. In addition to describing the effects, observers use the following system to rate the effects:

Extent:

- Pollutant has been mobilized off-site, but does not reach the stream channel; effects are evident near the site of the activity.
- Pollutant has been mobilized off-site and reaches the stream channel; effects are evident at the stream reach scale (<20 channel widths downstream).
- Pollutant has been mobilized off-site and reaches the stream channel; effects are evident at the drainage scale (>20 channel widths downstream), effects typically extending downstream and are expressed in larger order channels.

Duration:

- The pollutant or its effects dissipate within a very short (<5 day) period; they are typically associated with a single activity or precipitation event.
- The pollutant or its effects are observable for an intermediate (<1 season) duration; effects are typically expressed intermittently during high flow or precipitation events, dissipating to near background levels by the next wet season.
- The pollutant or its effects are observable for a long (>1 season) duration; effects are typically chronic and persist beyond the next wet season.

Magnitude:

- Effects to beneficial uses insignificant with no measurable water quality impairment; pollutant may be visible, but not likely detectable by compared measurements above and below the site.
- Effects to beneficial uses are minor with measurable water quality impacts the pollutant or its effects may be measurable up to the reach scale, but with no likely effect on biological or economic values.
- Effects to beneficial uses are significant with measurable water quality impacts resulting in degradation to biological or economic values.

The *User's Guide* (USDA-FS, Pacific Southwest Region, 2002) includes detailed instructions for completing each of the 29 on-site evaluation procedures. Included for each procedure is information on developing the sample pool; selecting evaluation sites; timing the evaluation; filling in the form; and the method used to do the observations, measurements, and recording for all the implementation and effectiveness criteria. Also included are hypothetical examples of a completed form for each procedure.

Important Points to Note About the BMPEP

Effectiveness criteria focus on site-specific indicators, which in most cases represent potential effects to water quality rather than actual effects. For example, rill erosion observed on a road would be listed as poor effectiveness, though any sediment from the erosion site that does reach a stream might have anywhere from a negligible to serious effect.

Observations could indicate that a BMP has been implemented but was not effective. Such results are useful as they indicate shortcomings of BMPs, that a BMP might be inappropriate for a particular area, or that the BMP was implemented poorly. Some form of improvement to the BMP is definitely needed in such a case.

BMPs with a high number of comments about the effects on water quality (potential or real) and/or high ratings of "implemented–not effective" are often those implemented close to water courses. Because of the greater potential of practices near water courses to affect water quality, it is prudent to prescribe conservative BMPs in these locations to provide adequate water quality protection.

It is important for foresters in a particular area to review the specific results from that area and not to rely solely a the regional summary that is generated from the individual evaluations. A BMP found to be effective in one area is not guaranteed have the same effectiveness whenever and wherever it is applied. Forest-specific results are more indicative of the changes that can be made to improve BMP effectiveness in a particular locality.