ABSTRACT: Forest water quality protection strategies in the United States are based on the implementation of Best Management Practices (BMPs), but are they effective? To answer this question we must answer five component questions. First, can BMPs be effective? We show that they can be effective. Second, how do we measure BMP effectiveness? Most state assessments of BMP effectiveness involve a qualitative evaluation. Still, there are many metrics and approaches for assessing BMP effectiveness. Third, are BMPs effective? The preponderance of data for relevant measures of effectiveness tells us they are. Fourth, where and when are BMPs effective? Whether a BMP is effective depends on site-specific conditions. Often, there is “conditioning” of BMPs to make them more effective. Finally, what are the consequences of BMPs that are judged ineffective? In most cases even BMPs that are not judged to be effective provide some level of protection.

KEYWORDS: Best Management Practices (BMPs), effectiveness, water quality
INTRODUCTION

Best Management Practices, or BMPs, are defined as “a practice or usually a combination of practices that are determined by a state or a designated planning agency to be the most effective and practical means (including technological, economic, and institutional considerations) of controlling point and nonpoint source pollutants at levels compatible with environmental quality goals” (Helms 1998). These practices are used to reduce forest management impacts on water quality and stream habitat to acceptable levels. Most programs for forestry designed to protect water quality, whether they are state programs or company policies, involve ensuring that there is a high rate of implementation of effective BMPs. However, questions are often raised as to whether the BMPs that have been adopted by a state, province, or company are effective. To answer, we suggest that we need to first answer five component questions:

- Can BMPs be effective?
- How do we measure BMP effectiveness?
- Are BMPs effective?
- Where and when are BMPs effective?
- What are the consequences of BMPs that are judged ineffective?

CAN BMPS BE EFFECTIVE?

First, we pose the somewhat rhetorical question, “Can BMPs be effective?” BMPs are based on an assumption that how we management forests can make a difference to environmental values including water quality, but is there proof of that? Clearly, there is evidence. One example is the Alsea Watershed Study in coastal Oregon, where harvesting with and without riparian protection was compared. Looking at just one water quality parameter, dissolved oxygen (DO), a stream that had its watershed nearly completely clearcut without riparian protection suffered a severe depression in surface water DO concentrations. This was an experimental treatment where trees were harvested to and felled into the channel. Factors contributing to the low DO concentrations included the extremely low discharge of the stream, removal of shade near the stream, introduction of fresh slash with a high biochemical oxygen demand, and even ponding of the streamflow, resulting in reduced reaeration (Ice 1990). In contrast, the stream where fresh slash was kept out of the channel and shade was retained did not suffer a severe reduction in surface water DO concentrations. Thus there is strong evidence that we can employ management practices that avoid or minimize water quality impacts.

HOW DO WE MEASURE BMP EFFECTIVENESS?

Next we must ask how we measure BMP effectiveness. This is not a trivial matter, as there are many approaches that can be used and these approaches have different levels of acceptance with agencies and the public. Most commonly, as part of nonpoint source control programs, states have used qualitative field assessments based on visual inspections of harvest sites to assess whether BMPs have been successful. A good example is the BMP assessment program in Montana, where trained inspectors visit forest sites every two years and assess whether roads and harvest units are complying with BMPs and if there is visual evidence that water quality has been
impaired (Ethridge n.d.). This usually involves observation of sediment plumes or obvious erosion. Critics note, however, that not all water quality impairment can be assessed visually.

Another approach is the use of watershed studies designed to test the effectiveness of state or company BMPs. An example is the Mica Creek Watershed study in northern Idaho. Mica Creek is an 11 mi² watershed owned and managed by Potlatch Corporation. Since 1990 Potlatch and cooperators have been monitoring discharge and water quality using a nested watershed design (McGreer et al. 1995). After a period of pre-harvest measurements, portions of the basin had road construction and timber harvesting and water quality response was monitored. Any water quality response can then be assessed to determine whether it is significant and warrants revision of the state BMPs or forest practice regulations.

Some states are trying to move to biological measurements of BMP effectiveness. For example, Oregon is implementing a bioassessment approach called RIVPACS (River Invertebrate Prediction and Classification System). This involves developing invertebrate prediction models based on reference streams. Measured invertebrate populations can then be compared to the predicted populations (Drake 2004). In Washington, where salmon issues are paramount, intensively monitored watersheds are being established to better understand how salmon and trout respond to habitat restoration efforts (Bilby et al. 2004).

What is clear is that there are different dimensions and scales that can be used to evaluate the effectiveness of BMPs (Ice 2004a). Some of these effectiveness dimensions include: reductions of physical or chemical loads compared with historic practices; reductions of physical or chemical loads using BMPs compared to unrestricted activities; effectiveness in meeting water quality or habitat goals; biological response to BMPs; comparison of BMP impacts with physical, chemical, and biological variations due to natural disturbances; and public acceptability of impacts from BMPs. BMPs must also be assessed to determine whether they are practical to apply (e.g., technologically, institutionally, and economically feasible). Each of these dimensions has value and limitations and can be assessed over narrow or broad spatial and temporal scales. The “art” of assessing BMP effectiveness is in selecting relevant dimensions and scales for testing and testing hypotheses that are answerable. In some cases, integrated measures of effectiveness, such as biological response, that directly answer policy concerns can be selected.

**ARE BMPS EFFECTIVE?**

We recently reviewed the history of BMPs and attempted to synthesize the information on just how effective BMPs are in reducing impacts to water quality (Ice 2004b). We found that BMPs were often from 80% to as much as 99% effective in reducing water quality impacts from forestry activities. An excellent example is a comparison of first year sediment losses from watersheds with and without BMPs in the Piedmont Region of the southern United States. Hewlett (1979) measured water quality impacts from then normal forestry activities and concluded that sediment losses from the watershed could have been reduced by 90% if there had been appropriate streamside buffers and well constructed and maintained roads, and if existing gullies had not been disturbed by machine planting. Williams et al. (2000) measured sediment losses for the same region, now with state BMPs implemented. They found sediment losses
similar to those predicted by Hewlett. These sediment losses were about what would have been expected simply due to increased runoff as a result of decreased evapotranspiration.

For some water quality issues BMPs have made even greater progress. Newton and Norgren (1977) reported that prior to the use of spray buffers, monitoring rarely found concentrations of herbicides exceeding 50 mg/L. Monitoring today rarely detects concentrations greater than 5 to 10 µg/L, or 1/10,000 the concentrations seen before BMPs (Dent and Robben 2000). These scales of pollution reduction are comparable to those observed for industrial or community wastewater treatment plants.

A *Control and Mitigation Handbook* which summarizes the effectiveness, costs, and limitations of specific BMPs for forestry is available on the NCASI website at [http://www.ncasi.org/Publications/Detail.aspx?id=2621](http://www.ncasi.org/Publications/Detail.aspx?id=2621). This handbook provides information on: the effectiveness of specific practices to control water quality impacts; the cost to apply the control measure; conditions that might limit effectiveness; complementary practices to improve performance; and literature citations on the control measure. There are plans to update this handbook and to adapt it for use in Canada. Shepard (2004) has also recently prepared a CD bibliography of literature on BMP effectiveness that includes 152 references with abstracts or full papers. There are plans to summarize this review into a formal paper later this year.

**WHERE AND WHEN ARE BMPS EFFECTIVE?**

Another relevant question is where and when are BMPs effective? A BMP that is effective in one location may not be effective in another. For example, Bilby and Ward (1989) found that the size of large wood that provides habitat functions for forest streams is related to stream size. BMPs that provide small wood recruitment may be effective for small headwater streams but not for wide, higher order streams. Similarly, even some headwater stream may have different wood recruitment needs depending on whether they are subject to debris torrents (and transport of wood downstream to higher order reaches). Thus, sites-specific conditions matter. To address this, BMPs are often adjusted to specific conditions. This is called “conditioning” and is done using various methods.

There are many approaches that have been employed to condition BMPs. In Washington, shade rules are based on the water type (stream temperature requirements) and elevation. BMPs are sometimes different for different regions, such as eastern or western Oregon. Stream buffers are sometimes conditioned based on slope and soil erodibility. Idaho bases wood recruitment needs on stream size, based on the work by Bilby and Ward described above.

Another consideration for BMPs is when or under what conditions will they be effective. Roads and culverts can fail when major storm events occur, causing large inputs of sediment to streams. It is becoming more common for BMPs to be designed to address these conditions; for example, the use of diversion-proof roads (designed to restrict loss of road prism to location of culvert failure) (Hagans and Weaver 1987).

**WHAT ARE THE CONSEQUENCES OF BMPS THAT ARE JUDGED INEFFECTIVE?**

Several years ago I served on an advisory committee for federal forests managed under the President’s Forest Plan for areas with northern spotted owl. This advisory group would
occasionally hear reports on monitoring to determine whether the plan’s riparian measures were being implemented and whether they were effective. I remember one incident where the inspection team had found a violation of the rules. In this case a harvest unit had preserved an appropriate riparian reserve for several hundred feet along both sides of a headwater stream. However, at the very top of the stream there was a road crossing and no buffer had been left above the road. There was debate among the inspection team about whether a channel could or could not be defined, but it was finally decided that a short reach of channel could be identified above the road and a riparian reserve should have been left. This interpretation was further confused because a fire-fighting pond had been excavated above the road. What concerned me about this was not that a minor misinterpretation of the riparian protection rules for a small fraction of the stream length had occurred, but that the whole activity was judged to be out of compliance. What further concerned me was that certain members of the advisory committee, who had never even seen the site, then declare this to be an ecological disaster and that the stream must be devastated by the intrusion. Most of the stream where active management was occurring remained extensively protected with a riparian buffer. The short reach stream above the road without a buffer probably had less impact on water quality than the road or fire-fighting pond.

BMPs will never be prefect. They will never achieve zero discharge of pollutants, nor will they come without any costs to landowners. The goal of BMPs is to reasonably reduce impacts so that our water resource goals can be achieve in a manner compatible with other natural resource goals. We often hear that everything in a watershed is connected to the stream, but there is a law of diminishing returns as we invest in water resource protection. The riparian area nearest the stream and other areas of the watershed hydrologically connect to stream (e.g., Variable Source Area, hyporheic zone) are disproportionately important for water quality and habitat. If 80% of shade for a stream is satisfied in the first 30 feet (Castelle and Johnson 2000), what are the consequences of leaving only 75 feet instead of 100 feet, and what about regeneration over time and the need for some disturbance to restore ecological functions? Even BMPs that are not “perfect” will often provide a high degree of protection to streams.

CONCLUSIONS

Clearly, how we manage forests makes a great difference in the impacts observed in forest streams. BMPs are designed to reduce these impacts to acceptable levels. There is strong evidence that BMPs are reducing water quality impacts by 90% or more. The key questions for the future are: how much is sufficient; what are the most useful metrics and scales to measure BMP effectiveness; and how do we include natural disturbances into BMP assessments?

LITERATURE CITED


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